AGRICULTURAL INNOVATIONS

2020

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Canada

Agricultural Innovations 2020

Catalogue No. A1-33E-PDF | ISSN 2562-0606 | AAFC No. 13073E
Paru également en français sous le titre, *Innovations en agriculture 2020*
For more information, reach us at www.agr.gc.ca or call us toll-free at 1-855-773-0241.

Contents

Agriculture and Agri-Food Canada's (AAFC) mission is to provide leadership in the growth and development of a competitive, innovative and sustainable Canadian agriculture and agri-food sector.

Our scientists work with their colleagues in industry, academia, indigenous communities, and provincial and territorial governments to support Canada's agriculture and agri-food sector, the Canadian economy and all Canadians through agricultural research and innovation. Our integrated national network of 20 research and development centres and 30 satellite research locations across Canada ensures a strong regional focus.

We understand the importance of agriculture to our economy, environment, communities, and human health. Our scientific breakthroughs are helping to:

- build resilience in the fight against climate change
- provide safe and sustainable crop protection
- keep our water safe and clean
- ensure access to healthy food
- reduce food waste
- provide food security in northern and indigenous communities, and more.

Over the past year, our scientists and staff were faced with unique challenges caused by the global pandemic. However, this threat to seriously affect scientists' ability to conduct their research proved no match for the hard work, flexibility, and extraordinary dedication of all our scientists and staff. From the beginning of the pandemic, they remained focused on supporting all AAFC science priorities by continuing on-site caring for livestock and biological organisms, transitioning to remote work whenever possible, and managing the gradual and safe return to activities in barns, greenhouses, and laboratories.

Looking to the future, we will continue to ensure our farmers, ranchers, and food processors have the best science-based evidence to help them thrive. The innovation and ingenuity of our scientists and staff are critical to ensuring all Canadians have safe, high quality food and Canada remains a world agricultural leader.

This publication highlights some of our current scientific accomplishments and shows how they benefit the agriculture and agri-food sector and stimulate the Canadian economy.

Agriculture and Agri-Food Canada (AAFC)

AAFC supports agricultural science through department-led research and investments in industry-led research.

AAFC scientists work with industry, provinces, territories, and academia to:

- Increase agricultural **productivity.**
- Enhance **environmental performance.**
- Improve **attributes** for food and non-food uses.
- Address the **threats** to the value chain.

IN THE AREAS OF:

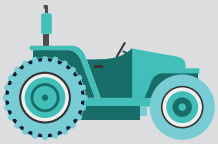
- Agri-food
- Agro-Ecosystem Resilience / Living Labs
- Biodiversity & Bioresources
- Cereals
- Clean Technologies
- Dairy, Pork, Poultry & other Livestock
- Forages & Beef
- Horticulture
- Oilseeds
- Pulses

Key Figures
2020–2021

2170 Science and Technology staff

717 Science and Technology projects

20 Research and development centres



30 Satellite research locations

1049 Science articles published in **397** journals

2020–21 INTELLECTUAL PROPERTY AND COMMERCIALIZATION

COLLABORATIVE RESEARCH AGREEMENTS

66 New Collaborative Research Agreements executed

153 New Material Transfer Agreements executed

230 Collaborators have executed Research Agreements with AAFC

PLANT VARIETIES

22 New varieties registered

16 New Plant Breeders' Rights granted

470 AAFC-developed varieties currently grown

PATENTS

14 New invention disclosures submitted

9 Patent applications submitted

5 New patents granted

162 Active patents in **32** countries for **52** technologies

COMMERCIALIZATION

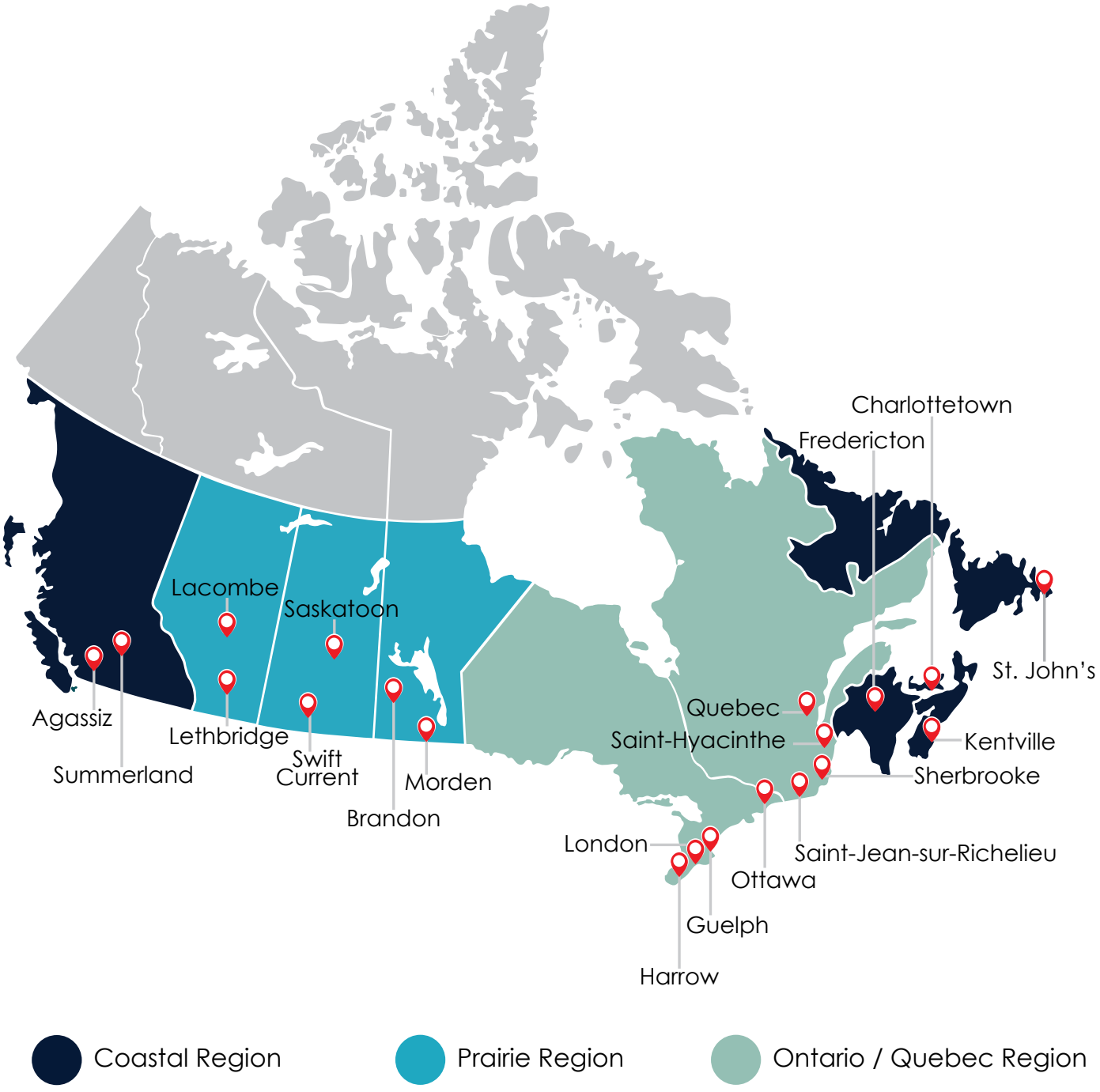
4 Business opportunity documents developed

14 Invention Disclosures assessed for their commercial potential

30 Commercialization License Agreements executed

686 Active licenses (technologies & varieties)

Research and Development Centres



Satellite Research Locations

COASTAL REGION	
Agassiz	**Clearbrook sub-station,** Abbotsford, British Columbia
Charlottetown	**Harrington Research Farm,** Harrington, Prince Edward Island – with field and greenhouse research facilities
Fredericton	**Benton Ridge sub-station**, Woodstock, New Brunswick – which supports germplasm enhancement activities
Kentville	**Nappan Research Farm,** Nappan, Nova Scotia **Dalhousie University's Agricultural Campus,** Truro, Nova Scotia
St. John's	**Avondale sub-station,** Avondale, Newfoundland

PRAIRIE REGION	
Morden	**The Canadian Centre for Agri-Food Research in Health and Medicine (CCARM),** located at the Albrechtsen Research Centre at St. Boniface Hospital, Winnipeg, Manitoba **The Richardson Centre for Functional Foods and Nutraceuticals (RCFFN),** located at the University of Manitoba, Fort Garry campus, Winnipeg, Manitoba **The Canadian Centre for Grain Storage Research,** located at the University of Manitoba, Fort Garry campus, Winnipeg, Manitoba **The Cereal Quality Laboratory,** Winnipeg, Manitoba
Brandon	**The Canada-Manitoba Crop Diversification Centre,** Carberry and Portage la Prairie, Manitoba
Lacombe	**Beaverlodge Research Farm,** Beaverlodge, Alberta **Calgary office,** Science and Technology Branch **Edmonton office,** Science and Technology Branch **University of Alberta,** Agriculture Life and Environmental Science, Edmonton, Alberta
Lethbridge	**Vauxhall Research Farm,** Vauxhall, Alberta
Saskatoon	**Melfort Research Farm,** Melfort, Saskatchewan **Scott Research Farm,** Scott, Saskatchewan **The Canada-Saskatchewan Irrigation Diversification Centre (CSIDC),** Outlook, Saskatchewan
Swift Current	**Indian Head Research Farm (IHRF),** Indian Head, Saskatchewan **Prairie Directorate Regina Office,** Regina, Saskatchewan

ONTARIO-QUEBEC REGION	
Harrow	**Honourable Eugene F. Whelan Experimental Farm,** Woodslee, Ontario **The Ontario Development and Technology Transfer unit,** Guelph, Ontario
London	**Research Farm at Vineland Station,** Vineland Station, Ontario
Quebec	**Saint-Augustin-de-Desmaures Research Farm,** Saint-Augustin-de-Desmaures, Quebec **Normandin Research Farm,** Normandin, Quebec
Saint-Jean-sur-Richelieu	**L'Acadie Experimental Farm,** Saint-Jean-sur-Richelieu, Quebec **Sainte-Clotilde Experimental Farm,** Sainte-Clotilde de Châteauguay, Quebec **Frelighsburg Experimental Site,** Frelighsburg, Quebec

Research During the Pandemic

Agriculture and Agri-Food Canada (AAFC) was able to safely resume the majority of research projects and activities that were paused at the onset of the pandemic. With the introduction of new technologies, AAFC researchers and staff were able to not only maintain but in many cases even increase their efficiency.

In 2021, AAFC plans to continue work on all current research, both indoor and outdoor, and to undertake additional research, as local/regional public health conditions allow.

PRODUCTIVITY

Agriculture and Agri-Food Canada (AAFC) science teams conduct research, development and technology transfer activities that significantly contribute to increasing the productivity of Canadian agriculture. Their work includes research that helps increase the yield potential of crops and improve feed efficiency for livestock by:

Increasing Agricultural Productivity

- Breeding new crop varieties of plants
- Improving the efficiency use of nutrients and water
- Improving soil conditions
- Using agricultural biodiversity for greater economic sustainability
- Protecting crops and animals from weeds, insects and diseases
- Reducing the impact of environmental stresses (e.g. cold, heat, and the salinity of soil)
- Finding suitable uses for marginal lands

The following stories are just a few examples of our most recent work in this area, and they may satisfy more than one agricultural objective.

Wheat Midge Adult (Photo by Mike Shillinglaw)

AAFC's Role in Advancing Wheat Improvement

Recently, a Canadian-led initiative unlocked the genetic code of 15 important wheat varieties, and Agriculture and Agri-Food Canada (AAFC) teams used this information to isolate a key gene of a major pest, allowing for the development of improved wheat varieties.

Five times larger than the human genome, the wheat genome (the entire genetic makeup or DNA) was once thought impossible to decipher. However in 2018, researchers, including scientists from AAFC, were finally able to fully sequence the wheat genome, a result of 13 years of work by the International Wheat Genome Sequencing Consortium involving 20 countries.

Wheat is a staple food around the globe, and we need to grow 1.6 percent more wheat annually on land where it is currently grown to meet future needs. Having a genetic sequence is crucial to producing hardier, high-yielding varieties resistant to diseases, pests, and a fluctuating climate.

By producing the sequence of 15 wheat varieties, researchers have now provided the most comprehensive atlas of wheat genome sequences ever reported. An AAFC-led study used this information to isolate the Sm1 gene, the only gene in Canadian varieties known to provide resistance to the orange wheat blossom midge, an insect pest that causes major damage to our wheat crops.

Thanks to international collaboration and scientific progress, we now have a better understanding of the extensive genetic diversity available in wheat grown in Canada and around the world.

Canada is one of the top 10 wheat-producing countries in the world and one of the top 5 wheat-exporting countries (2015 to 2018).

To Cut or Not to Cut? Timing Harvesting for More Milk

Thanks to a new decision support tool developed by Agriculture and Agri-Food Canada (AAFC) scientists, dairy farmers can improve their milk production by timing the harvest of their forage crops more effectively.

A cut field of hay in the Bas-Saint-Laurent region

In cooperation with industry, scientists developed this new web-based support tool to help producers get optimal quality and yield of their forages. Hosted on the AgWeather Quebec website, this platform provides farmers with current and accessible weather information to help them manage crop production.

The new tool uses a simulator adapted to Canadian conditions and AAFC-developed equations to simulate the growth of timothy, the main perennial forage grass used in Canada. Neutral Detergent Fiber (NDF) concentration, an indicator of forage quality, is also considered. To use the tool, producers simply select the closest weather station and the program provides a seven-day yield and NDF projection for timothy, so they can pick the best harvest time. This model also offers the possibility to expand it to other perennial forage crops such as alfalfa.Harvesting forages at the optimal time has an important impact on dairy farms' environmental and economic performance.

Farm cash receipts from Canadian dairy farming totaled $6.99 billion in 2019, with Quebec producing more than a third of all Canadian dairy.

Better Together: Participatory Approach Shows Benefits of Collaboration

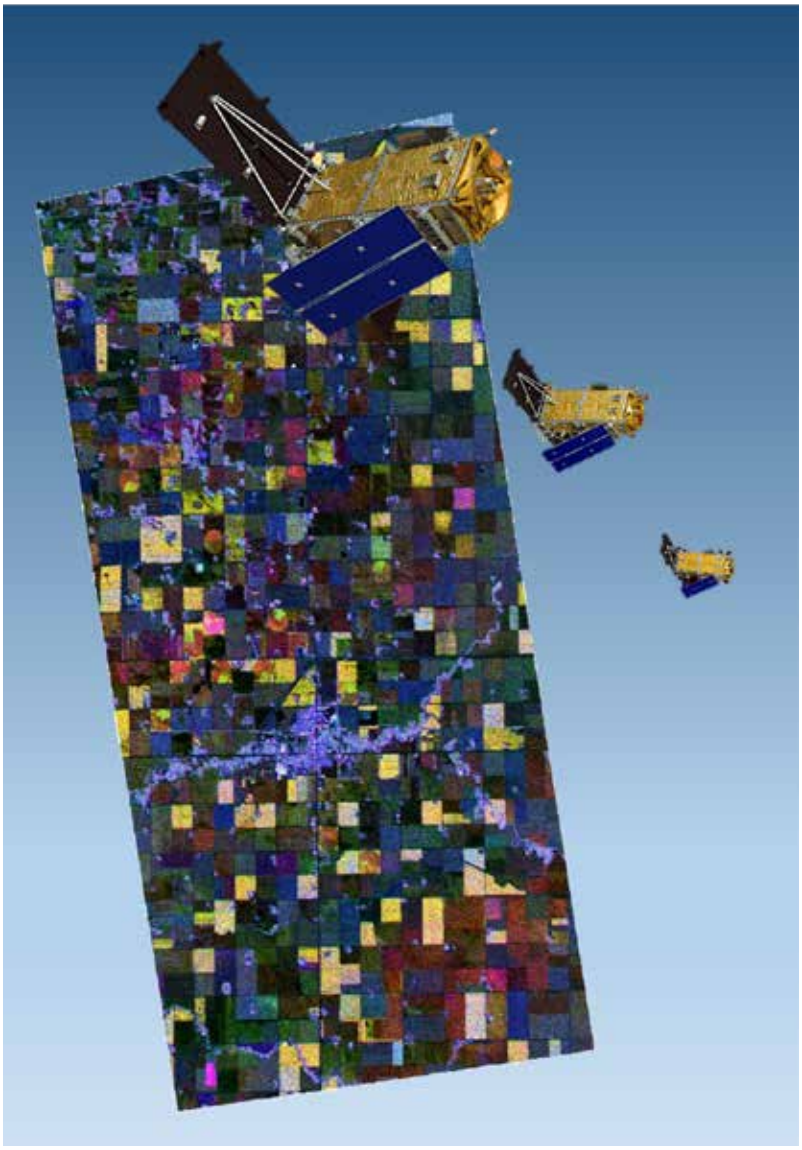
Cover crops in corn field in the Huron river watershed (Photo by César Largaespada)

Recently, Agriculture and Agri-Food Canada (AAFC) supported a participatory modelling initiative which is an integrated way to develop beneficial practices and technologies in real-life conditions, with farmers and stakeholders, as promoted by the Living Lab approach. This initiative encouraged farmers to adopt the practice of using cover crops by involving and supporting them in the research process. Quebec farmers saw the results first-hand from participating and were convinced to use cover crops on 10 local farms.

Cover crops, such as legumes and grasses, are planted after the main crop is harvested and known for their environmental benefits: preventing soil erosion, improving soil quality, and managing weeds, pests, and diseases. Choosing the right cover crop, knowing when to plant it, and caring for it can be complicated, requiring research and experimentation.

This participatory modelling exercise brought together local stakeholders for a series of workshops, including the Fédération de l'Union des producteurs agricoles (UPA) of Montérégie, producers, farm advisors, and an expert in participatory approach. The team examined crop rotations used by two farmers and collectively designed two prototype crop rotations that included beneficial cover crops. Researchers then tested the agro-environmental performance of these prototypes. Simulation results showed the many benefits of cover crops: stopping organic matter losses, and even increasing soil organic matter in some cases; reducing nitrogen leaching; and sustaining or increasing some crop yields.

The Final Frontier: Using Satellites to Increase Food Security



Multi-frequency Synthetic Aperture Radar image over cropland in Manitoba, 2020

As part of an international team, Agriculture and Agri-Food Canada (AAFC) scientists are using the latest satellite technology to find solutions for our planet's strained food production systems and respond by improving agricultural production worldwide.

In June 2011, the Group of Twenty (G20) Agricultural Ministers launched the Group on Earth Observation Global Agricultural Monitoring (GEOGLAM) initiative to increase market transparency and improve food security by strengthening the international community's capacity to use coordinated, comprehensive, and sustained Earth observations. GEOGLAM is a global collaboration, and participants include representatives from most G20 nations, many additional countries including from food insecure regions, several international organizations and NGOs.

Through GEOGLAM, AAFC is making a significant contribution to the development of a global monitoring system by: providing leadership for research coordination; putting Canada among the world leaders in agricultural monitoring; and helping to build global capacity. Experts from AAFC are heavily involved in all aspects of this collaboration, serving on the GEOGLAM Executive Committee and co-leading GEOGLAM's research and development arm, the Joint Experiment for Crop Assessment and Monitoring (JECAM).

Under JECAM, global teams are conducting experiments at more than 30 sites, throughout Europe, Asia, Africa, North America, and South America, chosen because they represent the planet's main cropping systems and agricultural practices. Satellites pass over these sites, collecting data from above, while researchers on the ground take measurements to corroborate the data and validate algorithms. JECAM data are shared among network participants, enabling unprecedented growth of global knowledge in this field. In Canada, there are three JECAM sites managed by AAFC which have developed methods that assess surface soil moisture, identify crop type, and monitor crop growth and productivity.

AAFC's involvement in these activities has already led to better operational agricultural monitoring systems in Canada which will continue to provide open data and value-added information products to the Canadian agricultural sector.

ENVIRONMENT

Another objective for Agriculture and Agri-Food Canada (AAFC) scientists is focussing on enhancing the environmental performance of Canadian agriculture, one of the major challenges facing producers in the 21st century. Our research helps ensure the environmental sustainability of the agricultural sector by:

Enhancing Environmental Performance

- Mitigating greenhouse gas production
- Improving the efficiency of nutrient use
- Improving soil quality
- Improving the management of water resources and energy in farming practices
- Enhancing integrated pest management practices (lower-risk pest control options)
- Reducing the environmental footprint of agriculture and agri-food production and processing

The following stories are just a few examples of our most recent work in this area, and they may satisfy more than one agricultural objective.

Living Laboratories Initiative

The Living Laboratories Initiative helps develop innovative solutions to environmental issues by focusing on three core principles:

- **Focusing on farmers' needs:** As the people who ultimately use these innovations, farmers are key collaborators throughout the entire process, testing the innovations, contributing knowledge and experience, every step of the way.
- **Broad and diverse partnerships:** Farmers, teams of scientists, and other collaborators contribute expertise and resources to develop innovative farming practices and technologies. These partnerships include First Nations, governmental institutions, industry representatives, non-profit organizations, and producer groups.
- **Testing in the real-life context:** The practices and technologies are tested, evaluated, and further improved in the context and scale in which they will be adopted: on local farms under real-life conditions.

The Atlantic (Prince Edward Island) Living Lab launched in 2019 followed by the eastern Prairies (Manitoba) and Quebec Living Labs in 2020. Ontario's Living Lab was launched in 2021.

LIVING LABORATORIES INITIATIVE

A NEW COLLABORATIVE APPROACH TO **AGRICULTURAL INNOVATION**

Farmers work with scientists from start to finish

Partners from various disciplines and backgrounds tackle a common issue

Working farms are the incubator of innovative technologies

EXPECTED OUTCOMES

More PRACTICAL TECHNOLOGIES and SUSTAINABLE FARMING PRACTICES ADOPTED MORE QUICKLY by Canadian farmers

WHAT ARE THE BENEFITS?

1. Strengthened ENVIRONMENTAL PROTECTION
2. Increased SUSTAINABLE AGRICULTURAL PRODUCTION
3. Improved RESILIENCE TO CLIMATE CHANGE

ISSUES TO TACKLE:

- Climate Change
- Soil Health
- Water Management
- Biodiversity
- Habitat Conservation

Find out more: agr.gc.ca/livinglab

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada | Canada

Okanagan vineyard in British Columbia (Photo by Dr. Sudarsana Poojari)

Raise a Glass to Healthy Canadian Vineyards!

With climate change bringing more erratic weather and new pests and diseases to vineyards, Agriculture and Agri-Food Canada (AAFC) scientists built a geographic information system (GIS) to help vineyard owners manage and track their crops' health.

Using this advanced tool, the researchers collect, analyze, and map vineyard characteristics, including terroir—the climate, topography, and soil characteristics that affect wine grape development and quality. The GIS is also used with drone imaging to detect and map terroir and crop characteristics such as water stress, nitrogen status, and disease. Vineyard owners receive GIS data and maps free of charge and use them to make decisions, such as when and where to irrigate, apply fertilizer, and treat or remove diseased vines.

Researchers are also using the GIS to study vineyard ecology and impacts of management practices. One study examined the effects of no-till viticulture and found it retains 25 percent higher soil carbon content than in nearby natural lands.

AAFC is currently expanding the GIS map inventory and refining techniques to:

- produce superior quality fruit and wines
- improve resource use efficiency and sustainability
- help inform proposals for new sub-appellations
- help build stronger brands for British Columbia's unique wines.

Grapes are Canada's 3rd most valuable fruit crop, worth $202 million in 2019.

Taking the Pulse of Field Crop Rotations

Agriculture and Agri-Food Canada (AAFC), in collaboration with University of Saskatchewan researchers, has identified the most effective pulse crops farmers should plant in their field rotation to improve soil health.

Pulse crops, such as beans, peas, and lentils, have the ability to increase nitrogen levels in the soil which is crucial for plant growth. Their root bacteria converts or "fixes" nitrogen from the air into a form that plants can absorb. Previous AAFC research showed growing pulse crops in rotation helps improve soil nitrogen, but not all pulse crops are equal in their contributions.

Comparing four pulse crops, they found:

- **Chickpeas** provided the most nitrogen to the soil, but did not fix the most nitrogen;
- **Faba beans** fixed the most nitrogen, but left little behind in the soil;
- **Chickpeas and lentils** were average in terms of nitrogen fixing performance;
- **Field peas** were the least performing.

From 1961 to 2014, the amount of nitrogen fertilizer applied globally increased more than 8x, affecting farm costs and the environment. Planting legumes is a viable alternative.

Farmers now have reliable information on how these pulse crops perform in similar conditions. This study showed high nitrogen fixation does not necessarily reflect nitrogen benefits to the soil. While all four pulse crops were beneficial, if farmers want to improve their crop rotation, rely less on commercial fertilizer, and maximize the yield of crop grown after them, they know chickpeas are a good choice.

Protecting Blueberries for Export Markets

Thanks to Agriculture and Agri-Food Canada (AAFC) research, blueberry growers now have new products to help sustainably control pests, like the blueberry maggot and mummy berry disease, and maintain access to important markets.

Canada is the world's second largest producer and exporter of fresh highbush blueberries and the top producer of lowbush, or wild, blueberries. However, exporting blueberries requires that our shipments meet quarantine and pest control standards, and compliance with the importing country's maximum residue limits (MRLs), the maximum amount of the active ingredient remaining on a crop after a pesticide treatment.

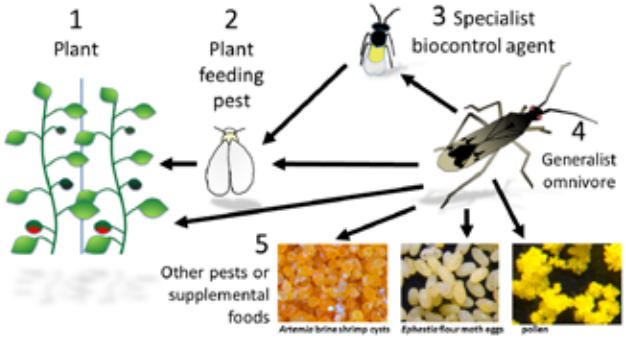
AAFC's Pest Management Centre (PMC) evaluates products to control insects, diseases, and weeds, and conducts residue studies required for regulatory assessment and registration of pesticides.

As of 2020, the PMC completed 56 blueberry minor use projects and submitted the results to Health Canada's Pest Management Regulatory Agency for product registration. This work supports new, safer and effective options allowing growers to diversify their pest management toolbox and replace older pesticides' uses lost due to regulatory re-evaluation.

In 2019, blueberries continued to be the most important food crop in terms of value ($270 million) and accounted for 23% of total fruit farm gate value.

Greenhouse Biocontrol: Keeping Bad Bugs Away with Good Bugs

Agriculture and Agri-Food Canada researchers found a new, sustainable and economical way to help producers protect their greenhouse vegetables – by providing the insects who feed on greenhouse vegetable pests with a well-balanced diet.



Greenhouse vegetables are vulnerable to pest insects, but they can be controlled by introducing predator insects ("good bugs") that eat the harmful "bad bugs." These biological control organisms work well as long as populations of these "good bugs" thrive, which can be challenging when their main source of food, the "bad bugs", is scarce. Re-introducing these beneficial insects every time there is a pest infestation in the greenhouse is expensive. Thankfully, researchers found a way to keep the "good bugs" thriving by providing them with supplementary food sources.

Testing focused on two beneficial insects that are native to North America: *Orius insidiosus* and *Dicyphus hesperus*. The supplementary food options for these included: Ephestia moth eggs, Artemia cysts, and cattail pollen (all harmless to crops). Results showed that both beneficial insects developed fastest and survived longest when Ephestia eggs were in their diet; however their preferences differed for their second food choice.

Total sales of greenhouse fruit and vegetables rose 5% to reach nearly $1.6 billion in 2019.

Since Ephestia eggs are the most expensive of the three foods, it's important to balance them with other less expensive types to keep costs down.

The Future is Here: AI in Greenhouse Production Wins Top Prize

Agriculture and Agri-Food Canada (AAFC) scientists joined artificial intelligence (AI) experts from Microsoft to win the first International Autonomous Greenhouse Challenge. Their efforts prove that indoor farming, using greenhouses and vertical farming coupled with AI, has the potential to quickly produce safe food while using fewer resources, including labour and pesticides.

The rules of the competition were to produce, in four months, cucumbers in the greenhouses of the Wageningen University & Research center (WUR) in the Netherlands. Using as few resources as possible, competing teams had to control their greenhouse and manage their crop remotely from other parts of the world. AAFC scientists joined Team Sonoma which provided the Microsoft AI expertise.

From their office in Harrow, Ontario, AAFC researchers provided horticultural advice and monitored the crops at WUR. Starting with a high density planting system, they adjusted the AI climate control based on crop performance and weather conditions to allow for best performance. Each day, they reviewed the cucumbers' growing conditions and gave instructions to Team Sonoma for their care.

The combination of high profit and sustainability saw Team Sonoma win the competition! At 55 kg of cucumbers per square metre, their net profit was 17 percent higher than that of the local expert growers, and 25 percent higher than that of the second place team.

This competition will serve as a benchmark for researchers and industry to help develop AI for greenhouses.

The winning cucumber crop from Team Sonoma, as seen in their greenhouse during the International Autonomous Greenhouse Challenge

ATTRIBUTES

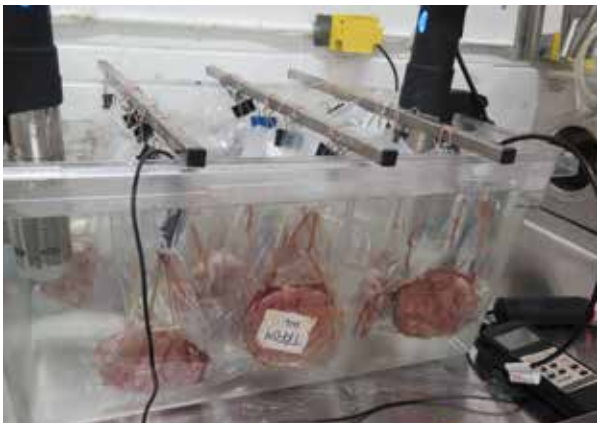
Agriculture and Agri-Food Canada's (AAFC) work also includes research, development and technology transfer activities which enhance the qualities and characteristics of foods and explore if certain commodities can be used for non-food uses. This area of research examines nutrition, health promotion and food/feed quality through:

Improving Attributes for Food and Non-Food Uses

- Increasing shelf life and post-harvest storage
- Enhancing food processing and packaging
- Making edible vaccines
- Improving marketable traits and characteristics
- Creating non-food, or industrial, uses which can be used in biofuels/bioenergy, feedstocks for pharmaceuticals, biochemicals, biopesticides and more

The following stories are just a few examples of our most recent work in this area, and they may satisfy more than one agricultural objective.

Sous-Vide Cooking means Su-perb Steak



Testing the sous-vide method of cooking beef

For some time, restaurants and food service companies have used the "sous-vide" method (cooking vacuum-packaged food in water) to retain moisture, enhance meat tenderness and pre-cook meat for quick re-heating. Scientists from Agriculture and Agri-Food Canada and Olds College in Alberta proved there are other important benefits.

To see if the sous-vide method could increase the tenderness of low value beef muscles, they compared three methods:

- a water bath to heat meat in a rapid but controlled manner (22 minutes in 70 degrees Celsius water reaching an internal meat temperature of 59 degrees)
- a single-stage sous-vide (one temperature over four hours), and
- a three-step sous-vide (three different temperatures over six hours)

They discovered both the single- and multi-stage sous-vide cooking methods increased meat tenderness compared to regular cooking techniques, with the multi-stage method being superior. They also found both the single- and multi-stage methods reduced the bacterial level on meat. Plus the multi-stage cooked meat may have an increased storage life capacity.

This research will equip the food service industry with knowledge to safely improve the tenderness and increase the value of low value beef cuts, potentially reducing food waste.

Whey to Go! Cost-effective Improvements for Artisanal Cheese Makers

Recent Agriculture and Agri-Food Canada research could help increase the yield of artisanal cheeses and reduce waste while providing new options for artisanal cheese makers and a better product for consumers.

Canadian cheese production ranges from large processing plants to small-scale artisanal cheese makers. Recovering whey protein, a useful by-product of cheese production, is a widespread practice in the larger milk processing plants. However, its technology is usually unaffordable for small dairy farms producing artisanal cheese. Consequently, they have often fed whey to livestock or discarded it. These smaller producers may now have a new process to recover whey protein so their businesses can affordably improve their cheese yield and quality.

Whey has useful protein that can be recovered and added back to the curd to improve cheese yield and better control moisture content and texture. Keeping the economic constraints of smaller producers in mind, scientists searched for alternatives to the expensive processes of ultrafiltration, separation, and homogenizer technologies used by large-scale producers. They found that gravity separation, combined with sediment drainage, is a viable alternative. It is less expensive and works well with cow, goat, and sheep milk, which is often what smaller producers are working with.

Canada is one of the biggest cheese-producing countries in the world, making:
- approximately 510 million kilograms and
- 1,450 types of cheese
(2018 statistics)

Keeping Chickens Healthy, Naturally

With Canada's poultry industry moving away from the widespread use of in-feed antibiotics, there is a need for new ways to protect the birds from infections. Agriculture and Agri-Food Canada has been studying the use of cranberries and other natural plant compounds in poultry, and the results
are promising.

In 2019, Canada's poultry industry produced $4.9 billion worth of poultry and eggs.

Cranberries are a potential natural remedy because they contain unique compounds and have shown encouraging results when tested in mice. In studies involving chickens, researchers found that purified cranberry extract could help fight bacterial and viral infections. The cranberry by-products directly weakened harmful bacteria and promoted the growth of beneficial bacteria in the chicken gut. This helped the chickens mount a stronger immune response against various pathogenic microbes including bacteria and viruses.

Scientists also found that encapsulated carvacrol (an essential oil in oregano), cinnamaldehyde (extracted from the bark of cinnamon trees) and citral (a compound in some spice plants) can help improve gut health and prevent gut disease in chickens. When added to feed, these compounds lessened the severity of gut damage caused by bacterial infection, working just as well as in-feed antibiotics.

These findings pave the way for more research into natural approaches to improve gut health and stimulate immunity in chickens while increasing their productivity and the safety of their products – all good news for Canadian poultry farmers and consumers.

Protecting Pigs with a Cucumber Virus

Canadian pig farmers could soon have a low-cost easy to administer vaccine that will make Porcine reproductive and respiratory syndrome virus (PRRSV) a thing of the past.

PRRSV causes fetal death of piglets and respiratory disease in pigs of all ages. Its devastating toll is what spurred Agriculture and Agri-Food scientists to search for a solution. Their unexpected ally was another virus that normally infects cucumber plants – the cucumber green mottle mosaic virus. It injects its genetic material inside the plant to replicate. Researchers used this virus as a vehicle to inject a fragment of PRRSV into cucumbers. The PRRSV fragment grew well inside the plant, turning into hundreds of copies in the leaves. The next step involves feeding these special cucumber plants to pigs to see if the PRRSV fragments trigger immunity against the disease.

Cucumber plants growing in an AAFC greenhouse

While more research is needed, the early success is promising as it could also lead to the development of vaccines for other diseases using the cucumber virus.

Porcine reproductive and respiratory syndrome virus (PRRSV) is currently the most costly threat to pork production in Canada, a $3 billion industry.

THREATS

The fourth objective for Agriculture and Agri-Food Canada's (AAFC) research teams involves addressing threats to the agriculture and agri-food value chain – from farmers with crops and livestock, to food processors, industry organizations, and the eventual end consumers. This research helps address significant production impacts by:

Addressing Threats to the Value Chain

- Ensuring food safety in agricultural production systems
- Ensuring food safety in processed and pre-packaged foods
- Addressing threats from the various environments of food production (insects, rainfall, soil, bacteria, birds, wild animals, gasses, etc.)

The following stories are just a few examples of our most recent work in this area, and they may satisfy more than one agricultural objective.

Canola: Keeping One Step Ahead of Blackleg Fungus

Agriculture and Agri-Food Canada has discovered two new resistance genes that enable canola to protect itself against a broad range of blackleg strains.

In the past, blackleg fungus was a serious disease, resulting in up to 50 percent losses in canola yields. Thanks to new varieties that were resistant to this fungal disease, reported cases plummeted. However, recent surveys show the disease is on the rise again as the blackleg fungus has been adapting and overcoming the resistance.

To help farmers, researchers started looking for new resistance genes that could be used to strengthen commercial canola cultivars. They screened more than a thousand different samples of canola and related crop species to see how well they withstood disease when infected with diverse blackleg strains. Eventually, they pinpointed the broad spectrum resistance genes, which they believe will be highly valuable for future canola production and breeding.

This research, along with good crop management practices, will help canola farmers stay ahead of blackleg disease and enable the industry to prosper.

According to the Canola Council of Canada, canola has an annual economic impact of $26.7 billion and is responsible for 177,000 jobs in Canada.

Tracking a Killer: Late Blight Pathogens

Although primarily known as a potato disease, the late blight pathogen is now being spread by tomatoes.

Late blight, a disease associated with the Irish Potato Famine, continues to wreak havoc worldwide. Caused by a fungus-like organism called *Phytophthora infestans*, it can spread quickly, killing crops that are part of the potato family within a few days of the symptoms becoming visible. Agriculture and Agri-Food Canada is leading a team to understand how and where various strains of the pathogen are distributed in Canada to control this deadly disease. They found that how it develops and spreads has completely changed in Canada over the last decade with new strains of the pathogen infecting crops.

Field-grown tomato plants severely damaged by the late blight pathogen

They also discovered:

- international and regional movement of infected tomatoes and potato seed are now key factors in spreading the disease;
- multiple strains, not previously present at the same time, are now often present in various regions;
- some tomato varieties were resistant to late blight and should be grown to reduce the spread of this disease;
- one commonly used fungicide is no longer effective in controlling many strains of the pathogen.

This increased understanding of the disease will help growers improve the way they manage the disease and lead to better economic returns for producers. Understanding the pathogen's optimal environments will also help scientists understand the impact of climate change on late blight and develop mitigation strategies.

The United National General Assembly named 2020 as the International Year of Plant Health, an opportunity to raise global awareness on how protecting plant health can help end hunger, reduce poverty, protect the environment, and boost economic development.

New Toolkit Takes the Bite Out of *Ips* Bark Beetles

Invasive insects such as *Ips* bark beetles threaten crops and forests around the world. Recently, Agriculture and Agri-Food (AAFC) experts led an international team to develop a new toolkit to help identify *Ips* bark beetles for the International Plant Protection Convention. The newly completed toolkit now makes it easier to identify *Ips* around the world, including 11 quarantine pest species.

To further develop this work, a second international team, including AAFC and Canadian Food Inspection Agency scientists, created an app of all 37 species and eight subspecies of *Ips* found globally. Users can select features about the insect such as characteristics of the main body, head, or geographic origin and host plant, and the app will eliminate non-matching species from the global list. Written for novice identifiers, it includes illustrated glossaries and fact sheets with rotatable 3-D images. These and other tools, now available on two websites (Lucid and Canadian Journal of Arthropod Identification), have already proven successful in helping plant and forestry organizations safeguard our plant resources. This research also increases our knowledge and helps us improve the way we monitor and identify insects that threaten crops around the world.

Ips Bark Beetle (Photo by Karine Savard)

A recent outbreak of *Ips* bark beetles resulted in 1.6 million hectares of land losing 15 to 30% of its pine trees.

Soybean cyst nematode (white lemon-shaped object) on soybean root (compared to the tip of a pen)

Cracking the DNA Code: Soybean Cyst Nematode

Researchers from Agriculture and Agri-Food Canada joined an international team of scientists and helped sequence the entire genome of the soybean cyst nematode. This crop parasite is responsible for more than a billion dollars of global soybean crop damage every year. Now, researchers can better understand how this parasite lives and how to control it by accessing its genome.

A genome is the entire genetic makeup of an organism and sequencing it means determining the entirety of the DNA sequence of that organism. Once a genome is sequenced and published, scientists can refer to it when studying particular genes, like the ones that control how the soybean cyst nematode infects plants. In the spring, the nematode hatches from eggs in the soil and infects nearby soybean roots, releasing proteins that transform the root cells into roomy growth chambers for the developing worm.

Understanding the genomics behind these proteins and how they work could lead to new ways of controlling the nematode. The sequencing of this genome could also help identify nematodes that have become resistant to current pest control methods, and provide another important tool to protect one of Canada's top field crops.

In Ontario and the Northern United States, the soybean cyst nematode is the most destructive of all soybean diseases. It is steadily spreading north throughout Ontario and into Quebec and Manitoba.

Antimicrobial Use in Cattle ≠ Antimicrobial Resistant Bacteria in Humans

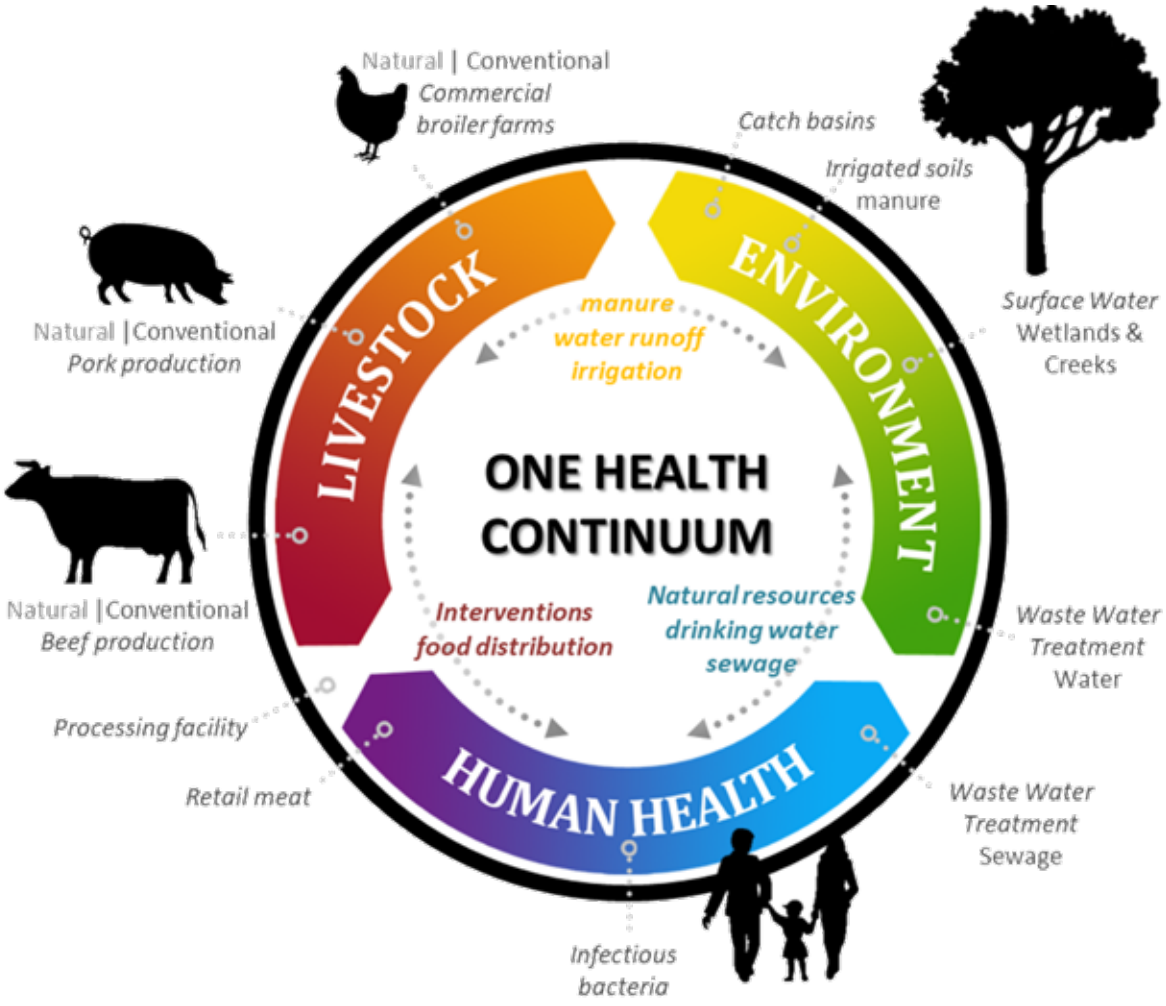
Antimicrobial resistance (AMR) is a serious concern for animal and human health, as some drugs become ineffective in treating bacterial infections. Bacteria with AMR are found in humans, animals, and the environment, and they may spread from one to the other. However, recent research shows that AMR bacteria in beef cattle differ from those that cause infectious disease in humans.

A team of two dozen scientists from five federal departments and agencies, academia and the private sector, led by Agriculture and Agri-Food Canada, studied bacteria from: hospital patients treated for infections, cattle in feedlots, waterways, processing plants, sewage plants, and elsewhere to see if there were any connections.

Using whole genome sequencing data, they found that potentially harmful bacteria in cattle are a different species from those threatening human health. Although some AMR genes were common across bacterial species, the majority found in human health-related bacteria were linked to antibiotics that are rarely used in cattle.

Through this research (under the Genomics Research and Development Initiative and the Beef Cluster), scientists understand better whether antibiotic use in the beef, pork, and poultry industries is increasing the risk of AMR in humans.

Although AMR in humans and cattle are likely separate issues, we must further investigate the possibility of AMR transfer in bacteria across the livestock-environment-human continuum and continue to use antimicrobials responsibly in both human and veterinary medicine.



Biovigilance – an Ounce of Prevention is Worth a Pound of Cure

A lettuce field in Ste-Clothilde (Quebec), part of a biovigilance pilot project

Growers face climate change, increasing pest problems, fewer and less effective pest control methods, and a growing demand for high quality foods. To meet these challenges, Agriculture and Agri-Food Canada (AAFC) is exploring a new way to protect the food supply, natural environment, and trade interests – a promising concept called biovigilance.

Biovigilance focusses on being proactive – preventing threats before they harm the agricultural sector and avoiding unintended impacts of production and pest management practices. Experts across specialties and jurisdictions work together to predict threats and stop them in their tracks. Scientists look at the entire production system, ensuring solving one problem does not create another, for more targeted solutions, delivered faster.

Currently there are three biovigilance pilot projects at AAFC for vegetables, field crops and grapevines. One supports Canada's vineyards by using molecular techniques to rapidly identify and understand the susceptibility of certain grapevines to disease. This knowledge is shared with growers to help them make more informed decisions in disease management.

AAFC is also leading a coordinated, national approach, working with partners through the International Bioeconomy Forum Plant Health Working Group, to develop a global plant health network using the biovigilance approach. As environmental conditions change and natural enemies of pests evolve, biovigilance will be critical in guiding our farming, business, science and program decisions.

The United Nations Food and Agriculture Organization estimates that between 20 to 40% of global crop production is lost to pests and diseases annually. Each year, plant diseases cost the global economy around US$220 billion, and invasive insects around US$70 billion.

The Stories Continue...

Agriculture and Agri-Food (AAFC) scientists and their teams are helping build a strong, healthy and innovative agricultural sector. You can find more stories about our scientific discoveries, new technologies and successes through these channels:

AGRI info

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

Good News Grows shines a light on the people making a difference in Canadian agriculture. From inspiring stories about farmers and AAFC scientists, to feel-good features about volunteers and youth, these stories show our agricultural future is in good hands.

Get to know some of our scientists through the Fields of Science campaign where we showcase how they help farmers improve and protect their crops to produce high quality food for Canadians and people around the world.

The **First Sixteen**
A **podcast** from Agriculture and Agri-Food Canada

The First Sixteen is AAFC's new podcast series that explores fresh ideas in agriculture and food. If you're interested in the people making breakthroughs and knocking down barriers, this is for you! New episodes every two weeks feature scientists, leaders, farmers and foodies with an eye on the future of the sector.

Facebook: @CanadianAgriculture

YouTube: AgricultureCanadaEng

Twitter: @AAFC_Canada

LinkedIn: Agriculture and Agri-Food Canada