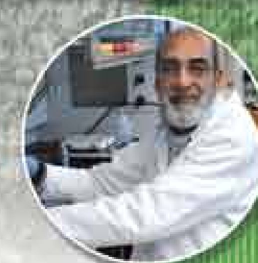
# A CENTURY OF SCIENCE



## With deep roots in agriculture, Potato Research Centre celebrates 100 years

Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton is 100 years old this year, a century of science that helped transform agriculture. But the centre's director of operations, Edward Hurley, says that may have only been the warm-up act.

"I think we are looking at another century of huge change," says Hurley. "Maybe even bigger than we've seen before."

That's a tall order. As game-changers go, 20th century science and technology re-wrote the way food was produced. The lights came on, horsepower replaced a horse's power, hybrid crops took a tougher stand in the field, computers came to the farm and DNA shed some of its secrets.

But Hurley is convinced we haven't seen anything yet, especially when it comes to Canada's largest and most lucrative vegetable crop. Four years after the United Nations named the potato as the food of the future for a hungry planet, the Potato Research Centre is continuing to unearth new opportunities for the spud.

It has become a go-to place for potato research in the international science community. It's linked closely with the International Potato Centre in Lima, Peru, and leading potato research centres in Europe. Working in close collaboration with the department's Lethbridge Research Centre in Alberta, the Potato Research Centre leads Canada's potato breeding program.

From a main facility just outside Fredericton and a research farm in Benton Ridge an hour west of the city, scientists are using molecular chemistry, a complete genetic map of the potato and a new understanding about the healing power of food to re-think the potato's potential.

For potato farmers like Joe Brennan, it could mean a future where more environmentally friendly new potato varieties get star billing on grocery shelves for their nutritional value, taste and, in some cases, their wild colours.


Potato Research Centre Director of Operations Edward Hurley.

"The need for change is probably greater than it has ever been," says Brennan, chair of the farm organization Potatoes New Brunswick and a grower who can trace his family's farm back to the 1860s. "Diversification is the next wave."

Hurley says diversification means looking at the potato not just as a food, but also as an ingredient. He expects potato starch will be one of those ingredients that will take hold in a bigger way in food processing and in a host of non-food products like biodegradable plastic.

Growing a better potato has been a goal of the Potato Research Centre since 1929, when it launched its potato breeding program. Since then, the centre has released 29 new varieties of potatoes, including Shepody, North America's second most-popular French fry variety. It currently has three new varieties going through the final stages of certification, the last step before being given a name and a launch into the marketplace.

But if the centre's future belongs to the potato, its past is deeply rooted in every aspect of agriculture.

When workers began clearing land for the new Fredericton Research Centre in September 1912, farmers in the region were struggling. Crops were plagued by low soil fertility and ravaging disease and insects. Livestock mortality was high. Scientists went to work evaluating new crops varieties and new breeds and looking at new ways to farm.

Along the way they tested more than a thousand varieties of vegetable and fruit crops and evaluated dozens of breeds of horses, dairy and beef cattle, pigs, sheep and chickens. Jennifer MacDonald, president of the Agricultural Alliance of New Brunswick, says the centre has played a crucial role for farmers and their industry.

"Our world has changed a lot in the last 100 years and the centre has helped us change with it," she says. "As farmers, we depend on research to keep our farms productive, competitive, and to help keep on delivering high quality products to the consumer. The importance of this is immeasurable."

## Inside

# An annual showcase on potential new varieties suggests the potato's best days may still be ahead

It's a cold day in February and the lobby of Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton has been turned into a potato showroom.

Thirteen different kinds of potatoes, piled in boxes, sit on a long table. One pile is purple. Another is red. One box is filled with tiny white potatoes not much bigger than golf balls.

These are the 2012 selections, the centre's best prospects for new potato varieties. More than 120,000 hybrid seedlings have been grown and tested and measured over six years and narrowed down to this baker's dozen.

Like concept cars at an auto show, the potatoes are still test models with names like AR-2012-02. And each has special features tailored for French fries, mashed, baked, chips and non-food uses.

But the selling points don't stop with the usual statistics about yield. Here, the discussion includes the environment, health and the cost of production.

Warren Road of Warren Grove Produce in Ontario has made the long trek to Fredericton to see what's new.

"This is an important event for us because we are always looking for a new and better potato," says Road, who is among the more than 60 potato breeders, farmers and processors from across the country checking out the potatoes in the lobby.

"This isn't just a commodity anymore," he says. "People want more bang for their buck and they want to know that the potato they are buying is special, that it looks good and tastes good."

The research centre's lead potato breeder, Dr. Benoit Bizimungu, couldn't agree more.

Although the centre's potato breeding program has been running since 1929, he says the 12-year-old showcase represents a new chapter in potato breeding.

"There is a combination of factors driving the demand for new potato varieties and it's all about higher expectations," he says.

For farmers, it's the rising expense of protecting the potato crop against diseases and insects.

"It's getting more and more costly to grow potatoes and make a profit, so low-input production is a very big thing for growers," says Bizimungu. "That means high yielding varieties with more natural resistance and less demanding fertilization requirements."

Sizing up the potential new potato varieties on display at the Potato Research Centre.

On top of that, low-input production means less stress on the environment. But Bizimungu says consumers are also demanding something new and different from the potato.

"Consumers are more aware of nutrition and the role food plays in their health," he says. "If we are going to see more potatoes on plates, we need to pay more attention to nutrition and the health benefits of potatoes."

This year's selections at the showcase seem to cover all the bases.

The star of the show is a low-glycemic potato. Although still years from the marketplace, it could be the answer for diabetics who have trouble with the sudden rush of blood sugar that comes with eating regular potatoes.

The other selections have their fans, as well. Most have better disease resistance and improved quality or niche potential. One is a starch factory, producing an above-average amount that can be used in food processing and industrial applications like biodegradable plastic.

But if there is a demand for difference, there is also a need for speed in coming up with new varieties to rapidly respond to the changing needs of the industry.

It's the reason why Road and the others in the lobby are more than just interested on-lookers. They will determine if any of these potential varieties make it to the marketplace.

For a $100 fee, they can conduct their own field trials and quality tests on a selection for up to two years. If they like what they see, they can bid to get exclusive rights to market the potato for up to five years.

"It's called the Accelerated Release Program," Bizimungu says. "Simply put, we want to get better and more novel potatoes into the hands of industry sooner," he says.

Instead of waiting for the research centre to complete what is traditionally a 10 to 12-year development process for new varieties, interesting selections are released to the industry at year six.

"We know by year six which selections have the potential to offer benefits to the industry and how the plants perform in the field," he says. "Industry can then judge them from the perspective of markets and production details."

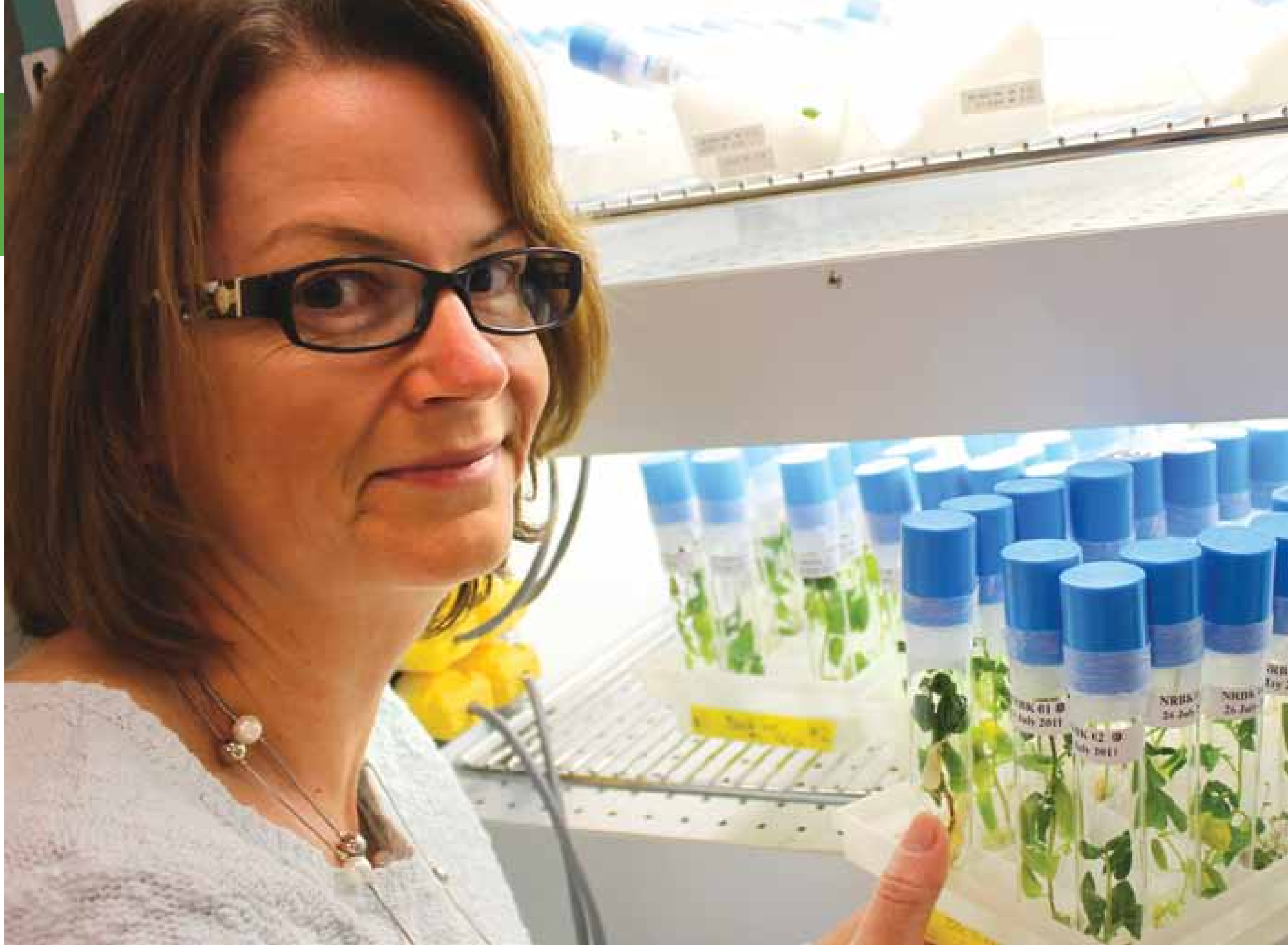
Negotiations are currently under way for exclusive licences for four selections.

Road supports the push to add more excitement and diversity to the potato.

"In our business, we are trying to find new ways to market potatoes and new varieties that will appeal to our customers. That's why it's great to come here and see all these different varieties side by side.

"We have the same goal – potatoes for everybody."

Potato breeder Dr. Benoit Bizimungu.



Teresa Molen with stored varieties in the Potato Gene Repository.

# Back to the future
## Collection of older potato varieties sows seeds for the future

When staff at the VanDusen Botanical Garden in Vancouver wanted to re-create an historically accurate English garden from 1850 to celebrate an anniversary, they turned to Teresa Molen and the Potato Gene Repository for help.

Months later, they were digging up a twisted, knobby potato called the Lumper from their heritage garden.

The repository at Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton is Canada's national gene bank for potatoes. It's a living library of 163 potato varieties and genetic stock, some dating back more than 200 years.

If the collection is a blast from the potato past for history buffs, it's also the launch pad for the future of the potato.

Inside what looks like three large fridges, small plants in racks of test tubes are the living repository of potato traits that otherwise might be lost in an industry dominated by just a handful of varieties.

"Our job is to preserve this diversity and keep it available for breeders and researchers," says Molen, who manages the collection.

Created in 1992, the repository was given a $500,000 upgrade two years ago to boost the security of the collection and expand lab space.

Sixty per cent of the plants are modern Canadian and international varieties and genetic lines that have shown good disease and insect resistance. The other 40 per cent are heritage varieties.

That includes the Lumper, a potato that gained infamy during the Irish Potato Famine of the 1840s and 1850s.

But if the Lumper was no match for a potato virus called late blight, it still could offer other traits that may be needed in new potato hybrids.

"We don't know what the future will bring and what we may need to deal with a changing climate, new consumer demands and new food and non-food uses for the potato," says Molen. "Some of these older varieties may have traits we can use."

Preserving this genetic diversity requires constant evaluation and maintenance. The small plantlets in the test tubes are grown from cuttings. They are renewed every two months, making the material available year round, and monitored regularly to make sure they are healthy.

Tiny potatoes called microtubers are harvested from the test tube potatoes and stored for up to one year as a precautionary back-up.

A duplicate collection of microtubers is kept at Agriculture and Agri-Food Canada's Saskatoon Research Centre in Saskatchewan.

The collection is part of a larger network safeguarding Canada's biodiversity called Plant Gene Resources of Canada. The Canadian network in turn is one of 300 members of a global alliance called BioVersity International.

While Molen hears from researchers across North America, she has been pleasantly surprised by the public's interest in the collection.

"People are very excited by some of these old heritage varieties and it's fun to work with them and to be part of these community projects."

"I've always enjoyed working with plants. This interest in the past, and the potential for the future, makes the job very rewarding."

# Kitchen research gives potato breeders something to chew on

Even after 23 years of biting into potatoes that have been cooked in almost every way possible, Denise LeBlanc still has a hunger for the job.

It's a good thing. LeBlanc is a member of a test panel that annually fries, bakes, boils and tastes more than 2,000 experimental selections at Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton, New Brunswick.

While her colleagues at the centre evaluate potatoes in fields, greenhouses and labs, LeBlanc and her team put potential new varieties through their culinary paces in a room called the quality lab.

Here, the lab equipment includes two ovens, a blancher, commercial electric fryers, a chip slicer, a French fry cutter and an instrument to analyze potato starch.

"Cooking quality is every bit as important as knowing how well a variety stands up to disease, pests and the weather," says LeBlanc. "At the end of the day, you want a potato that looks good and tastes good, a potato that consumers want."

When the quality lab opened in 1951, the average homemaker was spending over three hours a day preparing meals and feeding the family.

Today, the priorities are taste and convenience.

Gone is the idea that there is an all-purpose potato. Breeders select varieties with a specialization in mind, whether it is potato chips, French fries, baked potatoes, mashed potatoes or simple boiled spuds.

LeBlanc is one of five quality testers that rotate in three-person teams to rate a potato's appeal to the senses.

Mashed and baked potatoes are rated on a scale of one to five on appearance, texture, flavour and colour.

French fries are scored on external appearance and colour and internal colour and texture.

Potato chips are evaluated against a colour that ranks the chips from very light to very dark.

"Dark chips tend to have a bitter taste," LeBlanc explains.

While taste and appearance are subjective,

Deborah Campbell, Cynthia Murray, Esther Tremblay-Deveau, Denise LeBlanc and Stephen Allaby grade potato chips in the quality lab at the Potato Research Centre.

LeBlanc says the team is well-trained.

"We know what we are looking for," she says.

LeBlanc admits it is not a job for everyone.

"You have to love potatoes because you'll eat a lot of them," she says with a laugh. "And no, we don't use butter, sour cream, ketchup or any other condiment in the lab."

A cross is carried out on an emasculated potato flower where stamens have been removed.

Pollen is collected from the male parent and applied to the sigma of the female parent.

Pollinated flowers produce seed balls full of true seed that is used to plant the hybrids.

# You need to bring your bee game when developing new varieties

Stephen Allaby and Deborah Campbell know what it's like to be as busy as bees.

Every March, Allaby and Campbell would spend up to three months in the greenhouse taking pollen from the flower of one potato plant and using it to pollinate another.

It's all part of the painstaking process of cross-pollination used to breed new varieties of potatoes at Agriculture and Agri-Food Canada's Potato Research Centre.

Since 1929, potato breeding at the centre has changed dramatically. Genetic mapping, DNA fingerprinting and chemical analysis have made pinpointing desirable traits in potatoes a high-tech job.

There is a much larger choice of parents from among potato varieties found around the world, wild relatives and germplasm collections.

But the work of cross-pollinating potato plants to bring out those traits which growers, processors and consumers want is still very much a hands-on, manual process.

"This is traditional cross-breeding, the way we've been doing it for a long, long time," says Allaby. "We are using traditional and classical means of genetic modification."

This year, Allaby and Campbell estimate they did over 1000 crosses, with each cross involving 10 or more flowers.

In each case, they use tweezers to remove the male part of the flowers, called the anther, so the flowers will not self or cross pollinate on their own.

The crosses are chosen by the potato breeders who are looking to bring together the best traits from both plants.

"One may have great resistance to a plant disease and the other may have a lot of antioxidant activity that could have human health benefits," Campbell says.

The hybridization objectives are reviewed annually and tweaked to reflect changes in the industry and to address new trends or disease and pest challenges.

When the flower is fertilized, a fruit forms that is about the size of a cherry tomato and contains up to several hundred seeds.

Allaby, Campbell and their colleagues would then squeeze out the seeds from the thousands of fruit, recording the number of seeds from each ball.

The seeds are collected, numbered and stored in a seed inventory where they can remain viable for years.

When required, the seeds are grown in a greenhouse to produce potato plants that form tubers. The seeds from the same parents are sown together in groups so the plants they develop are like brothers and sisters, similar but unique. Each one has the potential to become a new variety.

From this point on, multiplication is done by planting potato seed pieces, each with two or more eyes, in test fields at Agriculture and Agri-Food Canada's Benton Ridge Research Farm. The plants that grow from these pieces are genetically identical.

Allaby and Campbell would then work with the potato breeding team to identify the best plants. These selections would then be multiplied and evaluated in field trials over several years. Those traits include growth and yield, disease and pest resistance and culinary quality.

"It is enjoyable work as long you can see what you are doing," Allaby says with a laugh. "It's up-close work. The bi-focals help, for us older bees."

# Benton Ridge Research Farm

## To make the cut, new potato varieties need to prove themselves in the field

It's August at Agriculture and Agri-Food Canada's Benton Ridge Research Farm and the potato crop is in bloom. But unlike the blossoming fields throughout New Brunswick's potato belt, this crop has a look all its own.

It starts with the metre-wide spacing between the plants, creating leafy islands on the dark soil.

Then there are the differences in shape, size and colour. White, yellow, pink and orange blossoms dot the plants. Some are single flowers and others have a dozen blossoms clumped in a bunch.

Some of the plants are globes of foliage hugging close to the ground. Others stand a metre high.

And then there is the sheer size of it all – 70,000 individual potato plants, each unique, planted across about 10 hectares of land.

These are the first generation of cross-pollinations from the Potato Research Centre's potato breeding program. After a year in the greenhouse, this is where future potato varieties begin their road test.

On another 20 hectares of fields on the farm, successive generations of potatoes are grown in more traditional rows. Only a dozen selections will make it through the next six years of testing for productivity, disease and insect resistance and hardiness.

It's all part of the long and intensive search for new varieties to meet the changing demands of farmers, processors and consumers.

"It's beautiful this time of year," says Tony Anderson, a field worker at the farm. "You can really appreciate how diverse potatoes can be."

Finding the best of that diversity has been the goal of the Benton Ridge Farm since it opened in 1975. Located 100 kilometres west of Fredericton, it provides the isolation needed to conduct field research lost when the City of Fredericton grew around the Potato Research Centre.

"We need to be as clean and controlled as we can be in a natural environment," says research farm manager Bill Flemming. "We're responsible for protecting the uniqueness of these potato selections."

The farm's six full-time staff and seasonal employees all understand the investment of time and effort that has already gone into the potatoes they grow in field trials.

Each plant represents a decision by the potato breeder on which two parents to bring together to tease out the desired traits. The work behind that decision can include molecular chemistry, DNA analysis and biological studies.

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Bill Flemming inspects a newly emerging potato crop at the Benton Ridge Research Farm.

# A return to the potato's wild side more than 40 years ago has Canada poised to take on the future

His grandchildren call him Spud.

His children laughingly recall trips to McDonalds that turned into lessons on French fry texture.

His wife remembers vacations that just happened to be near potato conferences.

For most of his life, Dr. Richard Tarn has been fascinated with potatoes. But four years after retiring, the legacy of Tarn's 40-year career at Agriculture and Agri-Food Canada's Potato Research Centre is still unfolding.

In the late 1960s, Tarn and fellow potato breeder Dr. Henry DeJong took the Canadian potato back to its Latin roots in the Andes Mountains of South America.

The influx of South American genetics has added a rainbow of pigments, odd shapes and wild varieties which look more like weeds than potatoes to the research centre's nearly 83-year-old potato breeding program.

That diversity may now be Canada's best advantage in taking on new market trends and a changing climate in the future.

"More than ever, we are in a marketplace and an environment that demands variation and that is only going to intensify," says Tarn. "When you look at the potatoes that grow in the high altitude of the Andes, you see varieties that have thrived for hundreds and even thousands of years with very few inputs like fertilizers or pesticides."

"Many of the varieties are quite small, but there is a diversity in shape, texture and colour of skin and flesh and we wanted to keep as much of that variation as we could."

It was concerns about the increasing lack of diversity in the Canadian potato crop that prompted the return to the potato's ancestral home.

In 1970, another major North American crop, corn, was hit by disease. Over 80 per cent of the corn had the same genetic background. It was uniformly susceptible to a new strain of south corn leaf blight and the crop was decimated.

Dr. Richard Tarn with some examples of potato diversity he helped bring into the Potato Research Centre breeding program.

It was a wake-up call.

"We recognized that the genetic base of our potato breeding material was so narrow that it was at risk," says Tarn. "We needed more variety of genetic material to ensure better resistance to disease and insect damage."

DeJong looked at wild species of South American potatoes while Tarn simultaneously looked at primitive cultivated potatoes from the region.

They began introducing traits from the South American potatoes into varieties being developed for the Canadian climate and market.

"When we crossed primitive cultivated potatoes from the Andes with our types, we got a boost in yields," says Tarn. "The primitive cultivars tended to produce a higher number of tubers that were small in size and our Canadian potatoes had a low set of tubers of a large size. When crossed, the hybrids produced a bigger yield of medium-sized potatoes."

The breeding material is now feeding research into varieties that go far beyond being just a staple food. The Potato Research Centre currently is developing varieties with human disease prevention, industrial applications and the environment in mind.

Tarn says this is the power of diversity. Diseases can mutate, insects can move north and markets can change, but they are not insurmountable problems when you have options.

"Our work has long-term implications," he says. "If we find ourselves in a situation where things are either going to work or not work because we don't have options, we will have a big problem.

"With variation, you can handle the stresses better."

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"We're dealing with irreplaceable seed stock," says Flemming. "If we lose a crop, years of research can go down the drain."

To keep that from happening, rigid sanitary standards are in place on the farm. Staff step into disinfectant baths when going into farm buildings and wear disposable plastic foot covers when going into fields. Equipment is steam-cleaned between fields.

The Canadian Food Inspection Agency inspects any potatoes that leave the farm for testing at Agriculture and Agri-Food Canada's research centres in other provinces.

With six generations of potatoes being grown at all times on the farm, Flemming says the work doesn't stop when the potatoes are harvested.

"The question I get all the time is what I do in the winter," he says. "Well, I'm picking out seed, buying chemicals and repairing and buying equipment.

"I am always getting ready for the next year."

# Scientists without borders

## The international appeal of potato research

When Latvian potato specialists Dr. Ilze Skrabule and Ilze Dimante visited Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton in mid-March, they were left wondering if Latvia and Canada truly did share the same weather patterns.

On the day of their visit, an unseasonable warm spell had bumped the temperature to 25 degrees Celsius and turned a winter day into a short-lived, short-sleeved reprieve.

But though the weather was surprising, the scientists got what they expected from scientists at the centre.

"The work is very impressive," said Skrabule, a potato breeder and head of the scientific board of the State Priekuli Plant Breeding Institute in Priekuli, Latvia. "The research is very high level.

"We hope we can cooperate in the future because we have very similar climates normally."

International guests are a regular occurrence at the research centre. A month before the Latvian visit, the centre hosted a Bolivian delegation.

French scientists have been working with Fredericton research staff on insect resistance at the centre's field plots in Benton Ridge and a French student is currently doing graduate work at the centre.

"We have world-class researchers and some very innovative work in potato breeding and the environmental side of potato production and that attracts attention," says research and development director Dr. Claudel Lemieux, explaining the international interest in the centre.

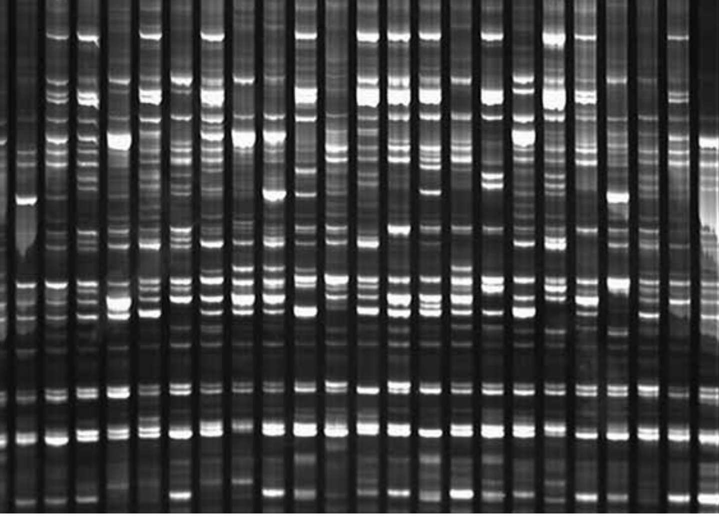
It's a two-way street. Last year, Dr. David De Koeyer, a leading Canadian scientist in potato genetics at the centre, spent 11 months at the International Potato Centre in Lima, Peru, looking at the genetics of potatoes in the high mountains of South America. That research is aimed at bringing benefits to Canadian growers.

"There really is a sense that we are an international community," says De Koeyer. "As scientists, we believe we can learn from each other and help our own farmers in that way."

But he adds that there is also a shared desire to use advances in the potato to help fight global hunger.

"I went to the Andes regions of Peru and met farmers who only want to be able to feed their families," he said. "The work we can do to make the production of potatoes more economical and the potato itself more nutritious will help people around the world."

Latvian potato researcher Ilze Dimante examines young potato plants stored at the Potato Research Centre with lead potato breeder Dr. Benoit Bizimungu.



# Varieties

## The Potato Research Centre helped map the potato's DNA

### Now a new journey begins towards the potato's future

When a Dutch-led science consortium announced in 2011 that it had completely mapped the DNA structure of the potato genome, Dr. David De Koeyer had a special reason to celebrate.

After all, he was one of the early surveyors.

"I was fortunate to be part of the Canadian Potato Genome Project between 2001 and 2005 and to lay the groundwork," says De Koeyer, a leading Canadian scientist in potato genetics at Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton.

With the genome sequence, De Koeyer and other researchers now know where to find each of the nearly 40,000 genes in a potato genome, even if they don't know yet what they all do.

The genes, along with some short and long strands of DNA, can be considered to be genetic markers. They are like sign posts on the highway announcing that you've reached your destination.

For potato breeders, the map will rapidly accelerate improvements in new potato varieties and open the door more fully to new uses ranging from medicine and health to manufacturing and energy.

"It's a game changer," says De Koeyer.

The work is not genetic modification, he adds. The genetic information simply makes traditional breeding more effective.

"The problem with potato breeding is that it's a very complex organism compared to other crops," he says. "It's very expensive and time-consuming to work with potatoes and get all the data we need to confidently say we have a good new potato variety."

Since potatoes have four copies of each gene compared to two in most crops – and humans – the probability of producing a desired trait is low.

Traditionally, it's meant greenhouse and field testing for up to 10 years to find the potato with the mix of traits being sought.

"Now, with this genetic marker information, we could potentially have that answer in two years," De Koeyer says. "This is the future."

Guided by the markers, researchers can now look for inherent resistance to specific diseases and insects.

"It's similar to the DNA research done on cancer and other human illnesses to help determine the course of treatment," he says. "We are applying very similar technologies to potatoes to predict better disease resistance and better quality."

The markers look like grocery store bar codes, lines of black and white of varying thicknesses.

The decoding of the genome has also given De Koeyer the ability to gather the DNA information on specific potato varieties. The data is generated at a genomics centre in Toronto and takes between two and three months.

He recently completed the sequencing of Shepody, a French fry variety developed at the Potato Research Centre that has become North American's second most popular variety for making fries.

"There are millions of variations between the varieties," De Koeyer explains. "It's just like people."

The DNA markers will not only make it easier to develop varieties that fare better in the field, but will also identify compounds in the potato for uses beyond agriculture.

"We can look for tolerances to stresses like drought and rain in a time of climate change," De Koeyer says. "We can look for aspects of nutrition, identify genes linked to improved health and traits important to cooking quality.

"DNA is the basis of everything. The more we understand the genetic make-up of the potato, the greater the potato's potential."

Dr. David De Koeyer calls the mapping of the potato genome a "game changer" when it comes to future uses for the potato.

## When you can't judge a potato by its cover, DNA fingerprinting makes the ID

What do the potato varieties Congo, British Columbia Blue, McIntosh Black, River John Blue and Sharon's Blue have in common? They are all the same potato.

Even potatoes, it turns out, can have an identity crisis.

"Especially with older varieties, we have found the same potato having four and five different names in different parts of the country," says Dr. Xiu-Qing Li, a molecular geneticist who developed a fast DNA fingerprinting technique to identify the genetic make-up of potatoes.

The identity confusion has its roots in the gardens and the fields of the last couple of centuries. Without the formal variety registration system now in place, people then would take it upon themselves to name their favourite potato variety.

The tradition has produced some colourful names. It has also produced headaches for potato breeders searching collections of heritage potatoes looking for traits to develop new and improved varieties.

"In potato breeding you have to know what you are dealing with," says Li. "We work with many hundreds of varieties, and looking at the shape and colour of the skin and flesh is not always enough to distinguish them."

But as Li worked on genetic identification, he found the process slow and expensive. The challenge was that each gene in a cultivated potato has four copies, twice that of a human.

In 2008, he led a team that developed one relatively simple test to produce a DNA fingerprint, a process called Multiplex SUPN. The test allows researchers to differentiate varieties mainly based on 14 bands of DNA sequences.

"We can now get identification in two days with just the one test, rather than having to do several tests," says Li.

The test was developed in collaboration with the Canadian Food Inspection Agency, the New Brunswick Department of Agriculture and the potato industry.

Dr. Xiu-Qing Li, a molecular geneticist, has developed a fast DNA fingerprinting technique to identify the genetic make-up of potatoes.

Li has created a library of more than 100 DNA fingerprints of Canadian potatoes and it continues to grow.

But DNA fingerprinting is more than an identification process for potatoes.

Muhammad Haroon, a technician working with Li, points to a DNA sample on his computer screen. It looks like a slightly messier version of the bar code you see in grocery stores.

"The genes and enzymes in potatoes tell a story," says Haroon, who worked on a human genome mapping project in Riyadh, Saudi Arabia, before immigrating to Canada.

DNA fingerprints are a reflection of genome and genes, which are responsible for characteristics like shape, size, texture and resistance to particular insects and disease. The genes could also help researchers breed potatoes with higher nutritional value and for non-food uses like bio-degradable plastic.

"We use the same techniques and technology in plant gene identification that are used to catalogue human genes," he says.

# The French (Fry) Revolution

*Would you like fries with that?* You bet. On average, each Canadian eats more than 29 kilograms of French fries and other processed potato products annually. There are even bigger fans around the world. It turns out that making a good French fry is a science. It's no surprise, then, that the Potato Research Centre has played a key role in the golden age of the fry.

## How an order of fries and a career in potato research led to the Order of Canada

You may not know what a Shepody potato looks like, but there is a good chance you've eaten one if you like French fries.

And if you like fries, you can thank Dr. Don Young for helping to give Canada a golden reputation for the fast food favourite.

The retired potato breeder at Agriculture and Agri-Food Canada's Potato Research Centre received the Order of Canada in 2009 for a 31-year career dedicated to potato research.

But it was the release of Shepody in 1980, after 17 years of work, for which Young may be best known in the potato world. Shepody was the first North American potato to be developed specifically for the French fry market and it quickly became the continent's second most popular French fry variety after the Russet Burbank.

New Brunswick-based McCain Foods, now the world's largest French fry supplier, was an early fan.

"The introduction of the Shepody potato is one of the contributing factors in the success of McCain Foods," says Dr. Yves Leclerc, the company's head of agronomy. "The variety's adaptability to various environments has allowed our company to expand our global activity and provide customers around the world with quality product."

Leclerc says the short-season Shepody allowed farmers and processors north of the border to compete with their American counterparts for the lucrative fast-food market.

Dr. Don Young, a retired potato breeder from Agriculture and Agri-Food Canada's Potato Research Centre, received the Order of Canada from the Governor General of Canada, Michaëlle Jean, in 2009 for his contributions to agriculture.

That market was still in its infancy when Young joined the research centre in 1957. It was the year the Russians launched Sputnik. On the ground, it was the spud that was taking off with new fast-food restaurant chains and consumer demand for convenience.

"The potato industry was with us from the start in the search for the next best thing in processing potatoes," recalls Young. "Farmers and processors wanted to know what kind of potatoes made the best French fries."

To find the answer, he started a research project in 1963 to define the physical and chemical characteristics of French fry quality. Then he and his team searched for those characteristics in a collection of 400 potato varieties.

In 1967, a cross was made between one of the centre's test potatoes, F58050, and a Cornell University variety called Bake King. The result of that cross showed promise in the field.

From then on, it was just a matter of growing and selecting the best plants.

Over and over again.

The odds of finding the superstar potato turned out to be somewhere between being struck by lightning and winning the lottery.

"During my career, I looked at over three million potential varieties to find what I wanted," says Young.

He's still pleased with the result.

Although Shepody has lost some of its sizzle to newer varieties, Young says the potato gave farmers and processors a competitive edge when they needed it.

"The fact that it matured earlier and was available six weeks before Russets meant farmers could start harvesting in the middle of August and get some money for the crop before their Russets came on," he says.

Shepody also needed 10 to 20 per cent less nitrogen than other varieties, saving farmers fertilizer costs.

For processors, it meant potatoes were available earlier in the year. "It lengthened their season," he says.

Young has fond memories of the work and his time at the research centre.

"It was really good fun," he says. "I think I had the best job in Canada."

## George Tai's inventions helped find gold in the French fry market

There's nothing like a good French fry – crisp and golden on the outside, white and fluffy on the inside.

But more than 40 years ago, fries were just as likely to be soggy and oily, with a few blackened ones thrown in. That's when plant geneticist Dr. George Tai and engineer Gerry Meisner became part of the French fry revolution.

They were working at Agriculture and Agri-Food Canada's Potato Research Centre in the 1960s when fast food restaurants really began to take off in North America. Burgers and fries became a take-out staple.

"We saw this huge jump in demand for French fries but the big challenge back then was finding the right kind of potatoes to process," recalls the now-retired Tai.

"If the flesh isn't concentrated enough, a French fry will absorb too much oil and it won't turn crispy and golden. If it's got too much sugar, it will turn black."

That meant finding potato varieties with less water and sugar.

It also meant some outside-the-box thinking. Tai, a grain specialist who admits he "hardly knew what a potato looked like" when he joined the centre, was ready to provide it.

Working with Meisner, Tai invented the Gravitator, a simple dunking machine to weigh potatoes in and out of water. It calculated the amount of dry matter in the potato by subtracting the amount of water, a calculation called specific gravity.

They then used another innovation of the time – the computer – to quickly calculate the percentage of dry matter in hundreds of varieties based on their specific gravity.

Their research was published in the American Potato Journal and the technique was soon being used around the world.

But Tai wasn't finished. He also developed a 30-second test to measure glucose levels in potatoes, using a strip similar to what is used by diabetics. This test, too, became an industry standard.

For Tai, it has all been about the numbers.

Dr. George Tai with the Gravitator, a simple machine that nevertheless was a golden invention for the French fry industry.

As important as the inventions have been, his most significant contribution to the industry was developing statistical methods to make sense of all the potato data being collected.

"We pioneered the technologies," says Tai. "It's very satisfying to see how the work has benefited the industry."

# History

Clearing research land in 1912.

## Potato Research Centre time line

**1910**

**1912** Oxen and horses used to clear 182 hectares for the Dominion Experimental Station.

The station's first director is W.W. Hubbard.

**1913** Poultry research begins.

A weather station is established. It is now a World Climate Program Reference Station, used in global warming studies.

**1914** 34 beef cattle and 35 dairy cattle purchased to study feed costs and pure-bred breeding.

Crop research begins.

**1916** First open house draws 1,200 farmers and their families from across New Brunswick.

A series of illustration stations are set up across New Brunswick to showcase new crop varieties and research results.

**1917** Yorkshire pig herd established.

**1920**

**1926** The director's residence, "Hilton House", opens.

**1928** Responding to the declining fertility of pastures in New Brunswick, research begins on the benefits of rotating grazing pastures.

**1929** Potato breeding begins. The station becomes the official home to Agriculture and Agri-Food Canada's national potato breeding program in 1934 under horticulturalist Louis C. Young.

Planting potatoes in 1913.

**1930**

**1934** Provincial agricultural school built at the research centre.

A corn trial in 1916.

**1938** Soil survey work begins. By the 1950s, soils in the province's important agricultural areas are classified and mapped.

**1940**

**1943** Centre named as Canada's potato breeding centre.

**1947** Alma, south of Moncton, New Brunswick, is chosen as a test field site for potato breeding and is used for the next 27 years.

**1948** A five-year study of oat varieties begins with the evaluation of 286 varieties.

**1949** Tower Hill Blueberry Sub-station established at Central Tower Hill, New Brunswick, to do research on low bush blueberries.

**1950**

**1950** Keswick and Canso, the first two potato varieties developed at the research centre, are released.

**1951** Cooking laboratory opened to compare the culinary properties of different potato varieties.

**1956** Lapin baking beans from Russia selected, improved and licensed for sale.

**1959**

Jean Adams checks cereal plants for damage caused by aphids.

# History

Weighing lambs.

**1960** Long-term fertilization trials begun to study the effect of fertilizers on yields.

**1962** Scientist Roy Bradley makes a major breakthrough in the control of the destructive potato virus PVY spread by aphids by showing how a spray of mineral oil blocks the transmission of the virus.

**1966** Research centre named Atlantic Canada Centre for Research in Animal Nutrition and Forage Production.

First agricultural research engineer in Atlantic Canada joins the research centre.

**1969** Potato breeding program focuses on South American potato varieties to breed new varieties with better resistance to disease and insects.

**1970**

**1971** Soil conservation research begins with on-farm monitoring projects.

**1975** Benton Ridge Potato Breeding sub-station opens 100 km west of Fredericton and continues today as the Potato Research Centre's site for seed multiplication, grading and storage studies.

**1978** Hervé J. Michaud Experimental Farm is established in Bouctouche, New Brunswick, to conduct research on fruits and vegetables.

**1980** The Shepody, a French fry potato developed by breeder Don Young, is registered as a variety. It becomes the second most popular fry variety behind the Russet Burbank.

Construction in 2002 as the research centre is expanded and upgraded.

Soils lab in 1953.

**1990**

**1995** Centre's beef research consolidated at the Nappan Experimental Farm in Nova Scotia.

**1996** Dairy herd is transferred to the Atlantic Dairy and Forage Institute, a private research organization established in Fredericton to serve the dairy producers of Atlantic Canada.

**1997** Centre renamed the Potato Research Centre.

**1998** Accelerated Release Program begins, allowing the potato industry to become involved earlier in the evaluation process required for a new potato variety.

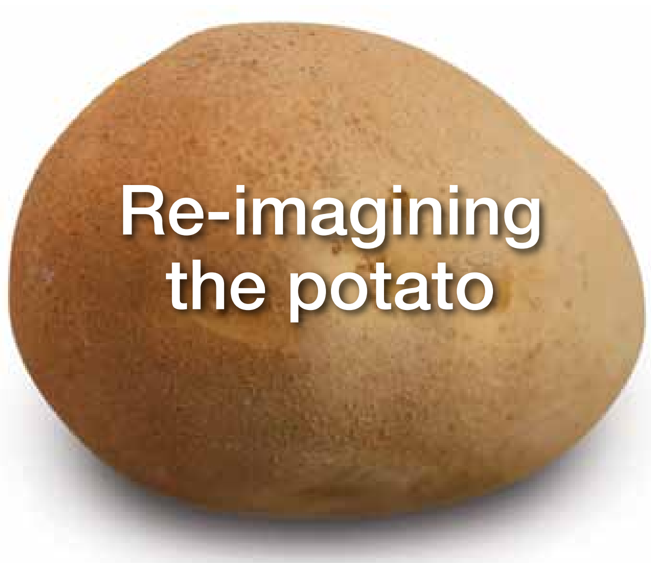
**2000** Potato Research Centre scientists work on a five-year project to sequence potato DNA. The results help an international effort led by Holland to map the entire potato genome in 2011.

**2003** The centre's 1950s-era laboratory building gets a $21.7 million facelift. The new facility contains more than 3,000 square metres of lab space.

**2008** Led by the Potato Research Centre, the Bio-Potato Network begins a three-year investigation into new uses for the potato.

**2011** The centre's Potato Gene Resources Repository, home to a national collection of more than 150 potato varieties from around the world, gets a $500,000 expansion.

A weaving class at Agricultural School in 1937. The school was located at the research centre.



# Re-imagining the potato

It was first grown as a crop 8,000 years ago by indigenous peoples in the Andes Mountains.

Today, there are more than 7,500 cultivated and wild varieties.

It is the world's number one non-grain food commodity, it is grown in more than 100 countries, and it is Canada's largest vegetable crop.

What else could we possibly get out of the potato?

Plenty, say the co-chairs of a Canadian scientific think tank that spent three years looking at the potential of the potato in the 21st century.

"Not only is there untapped potential for the potato as a healthy food, but there are alternative uses for potato that can generate new opportunities for growers," says Dr. Helen Tai, a molecular biologist at Agriculture and Agri-Food Canada's Potato Research Centre in Fredericton.

She and Dr. Yvan Pelletier, an entomologist at the centre, chaired the BioPotato Network, a three-year research project that wrapped up in 2011. The network involved 32 scientists and other experts from 11 federal and provincial research institutions, universities and the Culinary Institute of Canada.

The federal government invested $6.5 million in the network to spur new economic opportunities in a sector already worth more than $6 billion and responsible for more than 35,000 jobs.

"We knew going in that there are more things we can do with potatoes aside from boiling, mashing, baking and frying them," says Pelletier. "There is a fantastic diversity and complexity to potatoes we wanted to explore."

Working with cultivated potato varieties from around the world and wild varieties from South America, the group applied the latest advances in breeding, genetics, chemistry and materials science to tease out new possibilities.

The team studied all parts of the potato – including tubers and vines and from its smallest molecules to large polymers of starch – to develop health and pharmaceutical products, environmentally-friendly botanical pest controls and biodegradable plastic.

Researchers found health benefits from natural pigments present at high levels in some varieties, and developed new varieties with different forms of starch that are more tolerable for diabetics.

Part of the funding was used to purchase advanced equipment to enhance discovery and innovation. One piece of equipment, used for a process called reactive extrusion, has sped up the development of starch-based polymers that can be used for bioplastics and other industrial materials.

Another piece of equipment at the Potato Research Centre is a mass spectrometer. It was used to study small molecules in tubers involved in promoting human health and other molecules in vines that can boost plant resistance to insects to promote reduced chemical pesticide use.

But Tai says the most powerful and enduring aspect of the team's work may be the partnerships it has created.

"It has brought experts together from different disciplines to put many eyes on the potato," she says with a chuckle. "Seriously, when you have so many viewpoints, including that of a chef, it sparks ideas."

"Collaborations will continue."

# The potato's colourful side is gaining notice for more than its looks

Blue mashed.
Red fries.
Starburst potato chips.

Expect to see a healthy dose of colour in more of your potatoes in the future as scientists at Agriculture and Agri-Food Canada's Potato Research Centre introduce naturally pigmented potatoes into Canadian production.

There are currently dozens of coloured flesh varieties in the world. Most of them are growing in South America, the original home of the potato.

The colours – red, blue, orange, pale and egg-yolk yellow, purple and starburst designs of various hues – are natural pigments.

While blue potatoes have been a favourite side dish in parts of Atlantic Canada, Europe and South America for generations, coloured potatoes are still a novelty in much of North America.

But the eye-popping pigments are starting to attract attention – and not just for their looks.

Evidence of antioxidant activity three times higher than regular white potatoes is sparking interest among health-conscious consumers.

Like blueberries and spinach, potatoes with coloured flesh are rich in flavonoids such as anthocyanins and phenolics, which are molecular compounds that produce colour and have anti oxidant activity.

The ability of these flavonoids to neutralize cell-destroying free radicals in the body has been linked to anti-aging and the possible prevention of heart and blood diseases and cancer.

"People love the look of these potatoes but what is really making them attractive is the potential health benefits," says Agnes Murphy, a potato breeder at the centre who has been developing new coloured varieties since 2003.

Through selective breeding, Murphy's team is working on boosting the antioxidant level – and the colour – of new varieties of potatoes adapted to the Canadian climate.

Scientists at the Potato Research Centre first began looking at South American coloured potato varieties in the late 1960s. In the beginning, the focus was on yields and insect and disease resistance. They were also used to study the inheritance of pigmentation.

But in the past 15 years, researchers have discovered that there are lower levels of chronic illness and degenerative disease among populations that eat more fruits and vegetables.

The benefits of the potato, it turned out, aren't just about nutrition. There are lingering health benefits.

Last year, a team of Canadian biochemists working with the Potato Research Centre found that coloured potatoes have 35 per cent of the health-protecting antioxidant activity of berries.

"That may not sound like a lot, but Canadians eat a lot more potatoes than berries," says Murphy. "It's another economical source for these health properties, in addition to blueberries on your breakfast cereal."

Still, going from white to bright is a time-consuming process.

Of the hundreds of coloured hybrids Murphy's team has looked at, four have made it through six years of rigorous testing before release for commercial evaluation.

The selections are now being evaluated by industry to see how they perform in the field and what the market potential might be.

One purple fleshed selection is in its second year of exclusive field evaluation and will be eligible for licensing and registration if it makes the grade.

Agnes Murphy, potato breeder.

Murphy says it will probably be several years before these new selections are in the hands of growers and gardeners but she believes there is a bright future for the coloured spuds.

"They look different, are fun to cook with and they're great for you," she says. "I think that's a winning combination."

# Chef sees bright future in coloured potatoes

Working among chemists, geneticists and other scientific experts, chef Allan Williams adds a different viewpoint on the future of the potato.

Williams is one of the research and development chefs at Canada's Smartest Kitchen, a 12,000-square foot kitchen laboratory at the Culinary Institute of Canada in Charlottetown, PEI.

He worked with the BioPotato Network to cook up ways to turn the group's work on the health benefits of coloured potato varieties into food products to transfer those health benefits to consumers.

Researchers identified antioxidant activity in the coloured flesh varieties. Antioxidants in the diet have been linked to many health benefits including protection against cancer and neurodegeneration.

Among other things, Williams prepared the potatoes as chips, croquettes and soup.

The research group also developed potato granules with high levels of health bioactives that were used by the chef to develop new food concepts.

Williams says the granules are a convenient way to get potatoes into the processing sector and into the kitchens of time-pressed consumers.

But beyond the convenience, he added, the granules bring the two-fold advantage of colour and health benefits to processed foods and for restaurant and home meals.

"These potatoes have eye appeal, taste and aroma that today's consumers are looking for and health is on everyone's mind," says Williams.

Chef Allan Williams.

His favourite dish using coloured potatoes? Mushroom mashed potatoes.

# A diabetic-friendly potato


Potato breeders at Agriculture and Agri-Food Canada's Potato Research Centre may have found a potato that diabetics can love.

The research centre recently released a diabetic-friendly potato to the potato industry for further evaluation.

Diabetics have traditionally been leery of potatoes despite their high nutritional value. Potatoes typically contain rapidly digestible starch, which causes a sharp rise in blood sugar levels.

The new potato, still known by its experimental name AR-2012-04, is different.

"Potatoes are a great source of nutrition but they tend to be labeled as a bad food for diabetics," says Dr. Benoit Bizimungu, who led the development of this potato. "Many varieties are reported to have high glycemic index ratings, meaning the glucose moves quickly into the bloodstream."

"The benefit of a lower glycemic index potato like this one is that it doesn't cause a spike in the blood glucose level. Instead, you have a steady release into the bloodstream."

The discovery of the low glycemic index of this potato is the result of a research project involving Agriculture and Agri-Food Canada (Lethbridge Research Centre, Potato Research Centre and Guelph Food Research Centre), the University of Toronto and the University of Guelph.

Bizimungu led a team of plant breeders, food scientists, molecular biologists, nutrition scientists and plant production specialists looking for genetic and environmental factors that could lead to breeding and producing more diabetic-friendly potatoes.

From an initial 100 varieties and breeding selections, the group selected a few dozen for further testing. The evaluation included human trials measuring the effect eating the different potatoes would have on blood sugar.

As a result of the work, Bizimungu says researchers have identified several varieties and potato breeding lines that contain the kind of desirable, slowly digestible or resistant starch and dietary fibre they are looking for.

Bizimungu says the AR-2012-04 is probably still few years away from appearing on store shelves. But more low glycemic index potatoes could be on the way.

The Colorado Potato Beetle has a voracious appetite for potato leaves, but six wild potato varieties from South America are definitely not on its menu. Researchers in the BioPotato Network identified naturally produced chemicals in the wild leaves that are unpalatable to the potato sector's number one insect pest. Extracts can be made from the foliage and developed into a biopesticide in which the active ingredient is a natural compound. The wild varieties, which look like tomato plants with smaller leaves than a normal potato plant, are currently being crossed at the Potato Research Centre with domestic potatoes to create varieties that will perform well in the Canadian climate.

# The potato goes plastic

The future of the potato could not only be in the variety of the vegetable you eat, but also in the plastic bag you carry them in.

A BioPotato Network team of researchers at Agriculture and Agri-Food Canada's research centre in Guelph, Ontario, and McMaster University have been improving the process for making biodegradable bioplastic from potato starch. It is estimated that 500 billion plastic bags are used around the world every year, many of them ending up in landfills. Bioplastics can reduce plastic waste as they can be composted, but they require improvements to make them more marketable.

The team examined techniques for mixing potato starch and other polymers in the processing of bioplastic, and improving the quality of the plastic and reducing production costs.

They also solved one of the challenges of plastic from potato starch – its sensitivity to moisture – by adding biodegradable paraffin.

The innovations are making the bioplastics more competitive with traditional petroleum-based plastics.

Breeders at the Potato Research Centre have already developed new potato varieties with higher starch content than normal varieties. Demand for biodegradable plastics could create new market opportunities for potato growers.

# Science unearths a teeming, living world of potential in the soil

It's called deep sequencing and it's being used to explore one of the last undiscovered parts of our world.

The ocean? Space?

No, it's the soil.

"This is the last frontier," says molecular biologist Dr. Claudia Goyer, holding up a handful of soil in her lab at Agriculture and Agri-Food Canada's Potato Research Centre. "In just one gram of soil, we have literally millions of organisms and we know almost nothing about most of them."

That is changing. Goyer will soon be using a piece of equipment called a deep sequencer and powerful computer programs to take a more revealing census of soil.

By analyzing DNA samples of soil, the equipment is revealing a densely populated world of bacteria, fungi, bacteria-like archaea, insects and other micro-organisms.

It's a miniature community that, in the future, could help farmers financially by increasing crop yields and reducing the need for fertilizers, fungicides and insecticides.

At the same time, life in the soil holds the promise of making the business of growing food a greener industry.

"We know that we can change and influence these populations in the soil," says Goyer. "For example, we can create conditions where some of these populations can attack disease pathogens or even prevent them from establishing in the soil in the first place."

She recently demonstrated that with the discovery of a *Bacillus* bacterium in the soil. The bacterium inhibits the growth of another bacterium called *Streptomyces* that causes common scab.

It's an aptly descriptive disease. The bacteria infect the potatoes through natural openings in the skin and grow into rough, brown lesions, making the potatoes unmarketable.

Once common scab is in the soil, it's difficult to control or eliminate. Common scab is a headache for potato growers. The idea that the soil could police itself against the disease is appealing.

Goyer says her predecessors had the same appreciation of the soil as a living thing back when the Potato Research Centre opened in 1912. What they didn't have were the tools to see much of the life in the topsoil.

"Basically, all they could really do was dissolve a soil sample in liquid, shake it and then see what they could count with their eyes and under the microscopes of the day.

"Most of the things in the soil would have been undistinguishable to them."

The deep sequencer breaks down the DNA of all the organisms in the soil, producing millions and millions of pieces of genetic data.

Computers then put the puzzle pieces together, comparing genetic strands to organisms already known and pointing out the unknowns.

"If you think of it like a photograph, we can see into the soil with more resolution than we have ever had before," Goyer says. "We are finding all kinds of life that we didn't know was there."

This kind of powerful probing is the future of soil science, she says.

At the moment, deep sequencing has to be done by large sequencers in Quebec or Ontario.

But advances in the science could soon see deep sequencers the size of a microwave in many labs.

"We still have so much to learn about the soil," says Goyer. "It's an exciting time."

Dr. Claudia Goyer calls soil the "last frontier".

# Taking a page from the service station, researchers take a look under the potato's hood

When you want to check out the running condition of your car, you can take it into a garage and have it plugged into a computer. The machine will measure everything from fluid levels to the electrical charge in your battery.

Dr. Bernie Zebarth can see a day when roughly the same thing can be done with a potato plant.

Zebarth, a soil scientist at Agriculture and Agri-Food Canada's Potato Research Centre, is working with a diagnostic test that measures the activity of a particular gene in leaf tissue to tell when a potato plant needs more nitrogen, a chemical element necessary for photosynthesis and plant growth.

"It's basically the plant telling us how it's doing," says Zebarth, who developed the gene expression test with molecular biologist Dr. Helen Tai at the centre.

The information could help farmers save money on fertilizer costs and reduce the environmental risk of nitrates from excess nitrogen leaching into groundwater.

The gene Zebarth and Tai are focusing on is called a transporter gene. It pulls nitrogen through the leaf tissue to the areas where it is needed.

Zebarth uses a hole punch to take a sample from a potato leaf to conduct the test. The test detects the activity of the gene.

The gene is activated when the plant is low on nitrogen, allowing the plant to produce the proteins required to bring more nitrogen to where it is needed.

Zebarth says they still don't know that much about how the gene works. But he and Tai know that when there is a lot of activity with the gene, it's signalling to the plant that it needs more nitrogen.

"It's like the element in the thermostat in your house," Zebarth says. "When your house gets too cold, the element kicks in and it triggers the heat to come on."

The work is still in its early days. But the information could help farmers become much more precise in their applications of fertilizers.

"The challenge facing farmers is that nitrogen needs change from year to year and from field to field," says Zebarth. "Our goal is to match the amount of nitrogen to the plant's needs."

Zebarth believes this is the first step in a diagnostic test that could measure all kinds of stresses in a plant and provide an overall picture of the health of a crop.

"We are using gene expression now to look at nitrogen but there is no reason why this can't be expanded to look at a whole range of stresses, from ozone damage to potassium levels to drought."

"We still have a way to go but I think this is the future."

Dr. Bernie Zebarth takes a sample from a potato plant to measure its need for nitrogen.

# A closer look at insect behavior produces new insights into pest control

Dr. Yvan Pelletier tracks aphids feeding on potato leaves.

In Dr. Yvan Pelletier's lab, a barely visible aphid is feeding on a potato leaf hooked up to an electronic amplifier. A gold filament thinner than a hair is glued to the aphid's back. Each time the aphid's mouth parts penetrate the leaf, a line on a computer screen twitches.

Outside, Dr. Gilles Boiteau has a portable radar unit slung over his shoulder. He's tracking a Colorado Potato Beetle in a potato field. The beetle has a small wire glued to its back, pinpointing its location.

Welcome to agricultural pest research in the 21st century, where a renewed interest in insect behavior is giving new meaning to surveillance bugs.

Pelletier and Boiteau are entomologists at Agriculture and Agri-Food Canada's Potato Research Centre. Their work is shedding new light on the movements and habits of insects that cause an estimated $5 billion in lost potato production annually worldwide.

Dr. Gilles Boiteau and his portable radar unit.

"We are actually re-visiting a line of research that was popular about 50 years ago," says Pelletier. "What's new is that we have better monitoring technology now and a better understanding of the bugs through research on insect physiology."

Boiteau agrees. He was hired by the research centre in 1979 for his knowledge of Integrated Pest Management, or IPM. IPM uses knowledge of insect behavior, regular monitoring of their populations and a variety of control techniques to minimize yield loss while minimizing the environmental impact of controlling pests.

Those control methods can include traps, screen barriers and ditches around fields to catch insects moving on the ground.

"I think this is the future," he says of the tracking technology. "We need to take a more in-depth look at how these pests are moving through crops and the rest of the farm landscape."

Boiteau started tracking the Colorado Potato Beetle 12 years ago.

The beetle, which is shaped like a ladybug with black and yellow stripes, is one of the potato's most destructive pests. Both larva and adult beetles eat the leaves of the plant.

Boiteau worked with Fredericton electronics firm Cadmi Microelectronics and Dr. B.G. Colpitts of the Department of Electrical and Computer Engineering at the University of New Brunswick to come up with a portable radar tracking system. A diode glued to the beetle's back emits a signal that can be picked up by radar more than 30 metres away.

It may sound offbeat, but it has been revealing, says Boiteau.

"We are learning how much time beetles spend on the plants, how often they move and how far they go," he says. "The more we know about their dispersal, the more effective our control measures are going to be."

Researchers have also learned that the beetle, which is not native to Canada, has been a quick study when it comes to Canadian winters.

As winter approaches and the temperature dips, it produces a compound in its body that acts like anti-freeze. It then buries itself in the earth at the edge of potato fields to overwinter.

"It can survive temperatures as low as minus 7 Celcius," says Boiteau.

Pelletier is also learning more about aphids.

His probing monitor is designed to see exactly where in the plant's leaf structure the feeding aphids are picking up viruses, called PVY.

The aphids are the main culprits in spreading the virus from infected plants to healthy ones.

Fifty years ago, another scientist at the centre, Dr. Roy Bradley, discovered that spraying mineral oil on potato plants could dramatically reduce the spread of PVY.

Pelletier's tracking work is fine-tuning that preventative measure, providing more precise measurements of the amount of mineral oil needed and how it should be applied.

At the same time, he says advances in molecular methods are helping researchers understand the spread of PVY. That information could see control measures tailored specifically to a particular species for maximum effectiveness.

"We can now tell if an aphid caught in one of our insect traps has been probing a PVY-infected potato," Pelletier says.

Still, even with scientific advances, there have been practical problems to overcome to get on the trail of insects.

One of the most difficult parts of the radar project for the Colorado Potato Beetle was finding a way to attach the diode without restricting the movement of the insect.

"We're talking about a pretty small insect with a waxy shell," says Boiteau. "It took about four months of trial and error with different sizes of antennae and different adhesives to find a combination that worked."

A Colorado Potato Beetle wearing its tracking device.

# Foiled with oil

## Roy Bradley's discovery 50 years ago has saved countless potato crops

For an insect the size of a pin head, the aphid can cause big problems for farmers and gardeners around the world.

But thanks to a slick discovery by Dr. Roy Bradley 50 years ago, the aphid has been cut down to size when it comes to the spread of a major potato virus called PVY.

The virus weakens potato plants and reduces the number and size of potatoes a plant will produce. It can also leave marks on potatoes, making them unmarketable. In severe cases, PVY can lead to a total crop loss.

Bradley was a plant pathologist at Agriculture and Agri-Food Canada's Potato Research Centre in 1962 when he published a paper outlining a way to sabotage the aphid's ability to spread the virus PVY from infected potato plants to healthy ones.

His solution was to spray potato plants with mineral oil. It's a prevention method now used around the world.

It was an idea that came to Bradley once he determined how the little semi-transparent insect was picking up the virus.

"We knew aphids were responsible for transmitting the virus, but not a lot of research had been done on how they spread the virus and how to control that," he recalls. "I was fascinated."

Under magnification, Bradley saw how aphids used a thin, straw-like "mouth" called a stylet to puncture leaves and stems and suck sap from the plant.

"I discovered that aphids carry the virus on the tip of their stylet when they move to other plants," Bradley says.

He also found that a thin layer of oil on the plant prevented the aphid from picking up the virus in the first place.

"Spraying the plants with mineral oil reduced transmission to a very low level," says Bradley. "Combined with good agricultural practices, you can keep transmission to a minimum."

Current Potato Research Centre entomologist Yvan Pelletier says Bradley's discovery is still the basis of research today.

"He's still cited frequently," says Pelletier. "The method is not a 100 per cent solution but combined with other things like planting clean, virus-free seed, it gets close.

"Our work now is really about defining the action of the oil and how it interacts with the virus and the aphids to make it as effective as possible."

# How a reminder of the atomic era is helping farmers protect the water in New Brunswick's potato belt

A non-toxic left over from 1960s-era nuclear testing is part of an environmental fingerprint that is leading to cleaner water and better environmental practices in New Brunswick's potato belt.

Dr. Glenn Benoy is using the presence of radioisotope Cs-137 to help track the source of sediment and contamination in the waterways running through the 1,450-hectare Black Brook watershed in the northwestern part of the province.

Cs-137 was released to the atmosphere during atomic weapons testing in the 1960s and it settled on land around the world. It has since been covered over or redistributed by 50 years of soil erosion and tillage.

"It's not dangerous," says Benoy, an Environment Canada and Agriculture and Agri-Food Canada environmental scientist working at the Potato Research Centre. "The radiation levels of Cs-137 we measure reflect fallout levels that are measured all over the world.

"But it's an interesting marker or tracer for us because we can use it to identify soils and sediments from cultivated land," he says. "When it comes to soil in floodplains and sediments in waterways, it helps us determine whether the source contamination is the result of human activity, including farming, or from natural processes."

The radiation of Cs-137 is so low, in fact, it is necessary to block all other sources of ambient radiation so the Cs-137 can be detected. The soil samples are tested in a squat, one-tonne lead container with thick lead walls sheathed in copper.

Benoy uses the presence of Cs-137 and detailed physical characteristics like size and shape of sediment particles from streams and river systems to create an environmental fingerprint.

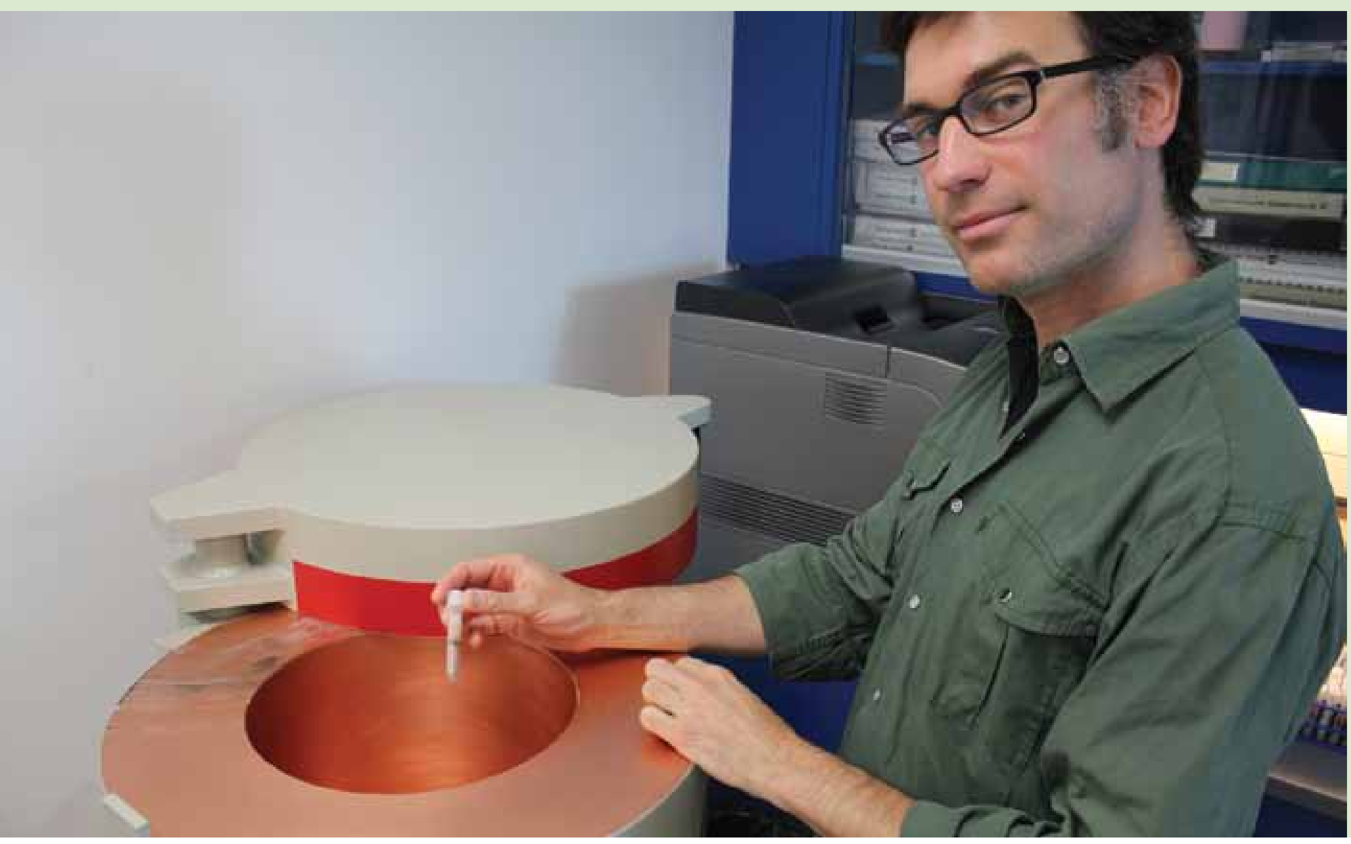
The fingerprint or profile is then compared against a library of soil-based environmental fingerprints taken from tilled fields, forests, road surfaces and other land uses throughout the watershed to pinpoint the source of contamination and where it entered the water.

"Any material entering a waterway has a chemical and physical signature that reflects the origin of the material," says Benoy.

"Not all of the contamination is from farmland. "In fact, this research shows that a lot of it is coming from other sources."

The information is helping farmers and other watershed users improve their environmental practices and develop more effective sustainable production strategies.

Partners in the project include Agriculture and Agri-Food Canada, Environment Canada, the University of New Brunswick and the farm group Potatoes New Brunswick.



Dr. Glenn Benoy gets ready to test a sample of soil for Cs-137, a radioisotope helping researchers pinpoint soil erosion.

# Virologist keeps farmers ahead of a potato virus as changeable as the flu

Dr. Xianzhou Nie thinks of the PVY virus as the potato's version of the flu. It comes back every year, but always a little differently.

But if it's a case of the flu for the plant, it's a major headache for farmers who can lose most of their crop to a nasty strain. In Canada, there are half a dozen major viral diseases that can hurt a potato crop. The PVY group is one of the most destructive.

Potato diseases have been part of the work of Agriculture and Agri-Food Canada's Potato research. Centre since it opened in 1912. And for a century, the goals have been the same – identify the disease, control and reduce the damage and work on new potato varieties with a natural resistance to the disease. PVY represents the challenge researchers continue to face today. Viruses change.

PVY occurs worldwide. The virus is spread in the field by aphids from infected plants. An infected plant will lose its vitality, producing fewer and smaller potatoes. A severe strain of PVY called PVYntn also leaves ring-like necrotic marks on certain varieties of potatoes, making them unmarketable.

There is no cure once a plant is infected with a virus, and the best way to minimize the effect of viruses is to plant clean seed.

In his lab, Nie is studying the molecular make-up of the PVY viruses to see what makes them tick and how they evolve. He and colleague Dr. Rdura Singh were the first researchers in the world to develop a diagnostic method to differentiate between different strains of PVY. The method is now used around the world.

"There are now many strains of the virus with varying characteristics and properties," says Nie. "We have to stay on top of the strains because different potato varieties respond differently to each of them."

His updates on the latest strains are provided to the Canadian Food Inspection Agency and farmers to spot symptoms of the virus in the field.

Nie also works with entomologists at the research centre to identify local species of aphids and other insects responsible for spreading the virus. Farmers can prevent the insects from carrying the virus to uninfected plants by spraying the crop with mineral oil.

But the best hope lies in developing new potato varieties that are resistant to the virus in the first place.

Last year, the research centre released a new potato selection with some PVY resistance. The selection is now being tested by potato breeders in the potato industry.

"A lot of progress is being made by our potato breeders," says Nie. "One day we will see potato varieties with extreme resistance to PVY."

Dr. Xianzhou Nie was one of the first researchers in the world to develop a diagnostic method to differentiate between different strains of PVY, a group of viruses that can devastate potato crops.

# A new dimension on water quality

Dr. Serban Danielescu is bringing a new dimension to the science of protecting water quality in agricultural areas.

The hydrologist, with both Agriculture and Agri-Food Canada and Environment Canada, is using cutting-edge technology to take a deeper look at the impact of agricultural production on water quality in the Black Brook Watershed. The watershed is a predominantly agricultural area in the heart of the potato belt in northern New Brunswick.

You can learn a lot by sampling water on the surface but what you don't learn how the water is running underground and where the contamination is below the surface," says Danielescu.

The work is part of long-term collaboration between Agriculture and Agri-Food Canada and Environment Canada to bring together leading researchers from inside and outside government to help farmers in Atlantic Canada protect water quality while staying productive. The team also includes members from the University of New Brunswick, Eastern Canada Soil and Water Conservation Centre, Nova Scotia Agricultural College, and the provincial government.

"We are developing models that will allow us to run simulations where we can track and study the quantity and quality of water from the time it reaches the surface of the ground until it reaches groundwater and further discharges into coastal waters or other bodies of water," Danielescu says.

"The idea is that once we have these models, we can play with the different scenarios. What happens if we cut pesticides? What happens if a changing climate affects rain patterns?"

Danielescu is collaborating with the University of New Brunswick to supply some of this data with ground-penetrating radar. The equipment looks like an industrial floor cleaner. It uses radar pulses that penetrate 10 metres into the ground to create images of the layered structures of soil, clay, rock and water. It helps to identify layers where the water is accumulating in the ground.

The ground below, he explains, is like a sponge. It holds water in its pores. But the sponge has long, winding tunnels that act as natural pipelines to carry the water across the watershed, coming to the surface in streams and other waterways.

To get a closer look at that flow, Danielescu and his team bore a hole in the ground into which they lower a miniature video camera to help identify cracks and tunnels carrying water.

"It helps us to identify particular fractures," Danielescu says. "These are important because we have to think about the long-distance effects of water contamination."

Together with work being done by Potato Research Centre colleague and fellow hydrologist Sheng Li, the team's research is being used to improve environmental practices on the farm to protect water quality.

"We are trying to provide the best possible tools for decision makers, including farmers," Danielescu says.

Hydrologist Dr. Serban Danielescu with a core sample of soil. New technology is taking the science of water quality below ground.

# A watershed moment for farming and the environment

When the soil is washing off your farm fields by the truckloads, you know you have to find a better way to stop soil erosion.

That's the position Alyre Poitras was in several years ago when he got involved in an environmental project in the Black Brook Watershed, in the potato belt of northern New Brunswick.

The Black Brook Watershed is one of nine Canadian watersheds being studied under Agriculture and Agri-Food Canada's Watershed Evaluation of Beneficial Management Projects.

The project was launched in 2004 to take environmental science in agriculture beyond small plot and field experiments, looking at the cost and the benefits of controlling water erosion on the farm when it comes to water quality in the entire 1,450-hectare Black Brook Watershed.

Poitras volunteered his St. Andre potato farm as a test case for researchers. To keep more of his soil out of nearby streams, he terraced his fields and grassed the waterways on his farm.

It worked.

"I used to pick up four or five loads of topsoil a year that had washed off the fields," Poitras says. "Now it's less than a load every five years."

That's the kind of story Potato Research Centre hydrologist Dr. Sheng Li likes to hear. Li joined the watershed project last year.

"We are trying to get a better understanding of the way water moves and how water running through a farm can be managed more efficiently," he says.

The work may be more important than ever as changing weather patterns produce more violent rain storms in the region. The Black Brook Watershed is prone to some of the most serious water erosion in Canada.

With a landscape of rolling hills and some steep slopes, the moving soil has at times led to high amounts of sediment and nutrients in the brook and streams running through the area.

About 65 per cent of the watershed is agricultural land and half of that is in potatoes.

Monitoring stations and instruments have been set up in streams to measure how much water is flowing from the watershed and what is in the water.

"This lets us take samples from streams to analyze for sediment and nutrient levels like nitrogen and phosphorous," says Li. "From our studies, we can recommend to farmers the beneficial practices they should follow on their farm to control water runoff and soil erosion."

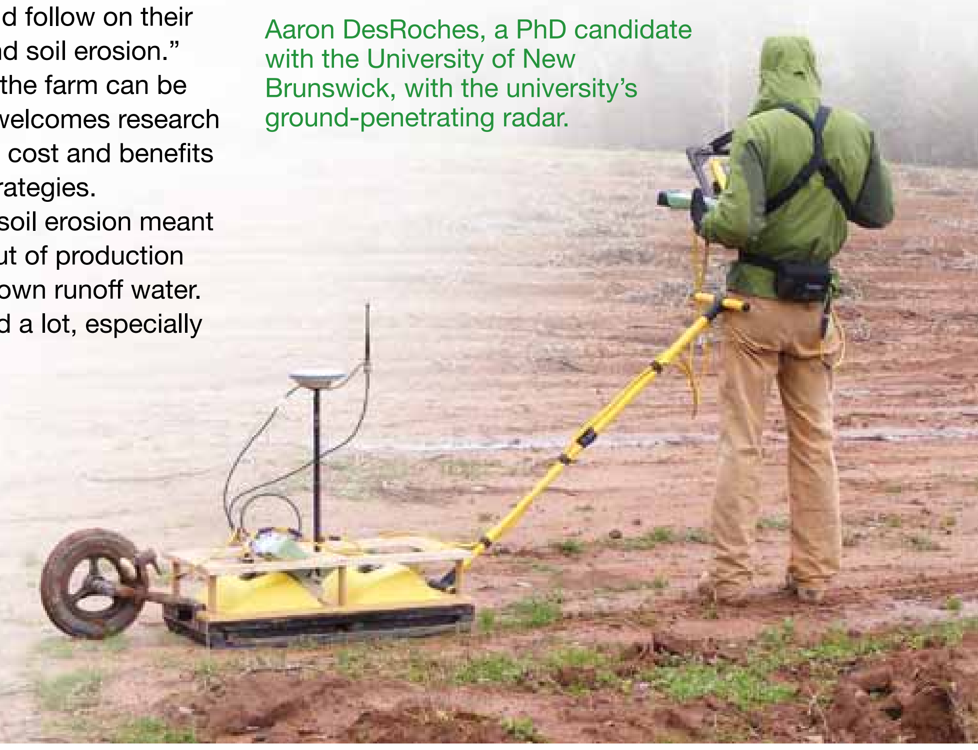
Environmental upgrades on the farm can be extremely expensive. Poitras welcomes research that includes solid data on the cost and benefits on particular environmental strategies.

In his own case, controlling soil erosion meant taking some of his farmland out of production to build the terraces to slow down runoff water.

"In the long-term, I've gained a lot, especially with the big thundershowers we've been seeing lately," Poitras says.

"We're not losing as much soil."

Armed to the teeth with flags, Dr. Sheng Li marks sediment build-up in the Black Brook Watershed.



Aaron DesRoches, a PhD candidate with the University of New Brunswick, with the university's ground-penetrating radar.

# People

## Team effort behind centre's century of science

As staff at Agriculture and Agri-Food Canada's Potato Research Centre gather for a group photograph, it quickly becomes clear that science is a community of skills.

Standing in the group are scientists, technicians, field crews, information technology specialists, financial officers, engineers and office staff.

"It's a team effort and it's been that way since the centre opened in 1912," says director research and development Dr. Claudel Lemieux. "There is a creative energy when people get together and good science thrives on that.

"We have people who are passionate about their work and committed to the idea of advancing agriculture."

Dr. Bernie Zebarth, who has worked at the centre for more than 30 years, agrees. In fact, he says the spirit of collaboration has intensified over the last 10 years.

"We are very closely integrated now and the nice thing about that is we each learn about the other person's field of work," he says. "We get a broader perspective and because of that we are better able to match our work to the needs of farmers."

Hydrologist Dr. Sheng Li, the centre's newest scientist, appreciates the openness of staff.

"I feel I can always ask questions and ask for help from other scientists," says Li. "I can just knock. They are really helpful."

As a commissionaire at the centre, Eli Lanteigne is usually the first person visitors see when they enter the research centre. He is always smiling.

"We make the visitor feel welcome," he says, "and that is reflected in the mood throughout the centre. The staff are here to help and we work as a team. It works very well."

Since 1912, over 300 full-time people have worked at the centre, as well as hundreds of seasonal workers and students. In many cases, their work has been measured in decades.

"There is a strong feeling of pride and accomplishment here," says director of operations Edward Hurley. "Our centre has a reputation based on 100 years of research that is bringing the world to our door.

"When you feel passionate about what you do, it's easy to come to work."

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