
# POTATO GENE RESOURCES

Number 26 • 2019/2020

## Striving toward consistent crop nutrition for improved human health in a changing climate

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The frequency of long arid summers are predicted to be on the rise as climate change continues to alter our landscape. Potatoes, being a temperate species well-adapted to temperatures between 15 – 20 °C, are more susceptible to hot and dry conditions than other widely grown Canadian crops such as wheat. As the fourth most consumed food crop, potatoes are one of the largest sources of dietary antioxidants in North American. Due to our caloric and nutritional dependence on this crop, it is important that we understand drought-induced gene regulatory cascades in potato tubers and their downstream impacts on tuber nutritional quality. This level of exploration has been made possible in recent years due to concerted and on-going genome sequencing and annotation efforts by the International Potato Genome Sequencing Consortium and contributions of independent researchers to maintained public databases such as NCBI, EnsemblPlants, Spud DB and the University of Toronto hosted ePlant.

Advancements in next-generation sequencing (NGS) for both mRNA and small RNA sequencing allow us to gain in-depth information on gene expression and regulation, but cost barriers limit the number of cultivars in which it can be explored. For this drought trial, the Canadian cultivar ‘Vigor’, a commercial yellow-fleshed chipping variety developed by the AAFC Lethbridge Research and Development Centre, was used as a representative cultivar to identify the drought-affected pathways. A gradual drought stress was applied to potato plots to better mimic field conditions (Figure 1). This work was made possible through a collaboration between Fredericton and Saskatoon AAFC research centres and the National Research Council Canada (NRC). By identifying of major drought-affected pathways in potato, we aimed to focus-in on which genes and phenotypes are crucial in maintaining crop nutrition as we work towards building drought-tolerance in high-yielding cultivars.

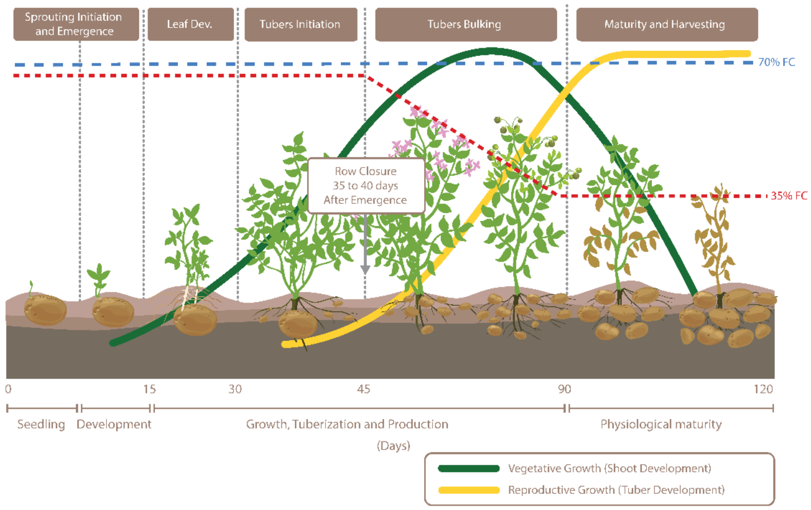



*Figure 1: Visualization of potato growth stages and in-season soil moisture trends maintained during the drought trial. Tuber samples for metabolomic and transcriptomic data were collected at 106 days after planting.*

**Transcriptomic and phenotypic responses to soil moisture deficit**

To date, the vast majority of studies examining drought have looked at gene transcriptional changes in leaf and stolon tissues, which can have major impacts on yield but may not tell us what changes are happening to the food we eat. Low levels of soil moisture often occur towards the end of the field season and producers are less likely to irrigate during maturation as it would prolong growth and affect skin set in the potato tubers. In the potato tubers collected 106 days after planting, gene expression clearly indicated drought signaling pathways had been activated and the list of differential expressed genes was similar to those seen in the above-ground vegetative tissue. ABA receptors, auxin-related genes and heat shock proteins were all affected. Opposite expression patterns of some developmental genes were observed in potato tubers when compared to literature reports of their expression in leaves. With regards to important dietary metabolites, five patatin genes, five key genes in the phenylpropanoid pathway genes and two key genes in the carotenoid pathway were significantly downregulated by at least four-fold (Figure 2). Patatins can account for up to 40 % of soluble protein storage in tubers and phenolic reductions in drought-stressed tubers were supported by the two-fold increase in accumulation of phenylalanine. Such accumulation is expected with a reduced flow through the phenylpropanoid pathway (Figure 2). Environmental variability and end-of-season conditions could therefore minimize gains achieved by breeding programs for these nutritional traits. Gene regulatory elements, in the form of known transcription factor families and small RNA, were examined for potential targets in reducing the extent to which these pathways were suppressed. MYB transcription factors are known to play prominent roles in regulating phenolic biosynthetic pathways and fifteen were downregulated by more than four-fold under drought. While no transcription factor families were correlated with patatin gene expression, 16 small RNA clusters were up-regulated and expression was inversely correlated (r= - 0.61) to patatin expression. This opens the door to targeting MYB transcription factors for better phenolic production under drought as no small RNAs were implicated in regulation. Possible reductions of soluble protein will be more difficult to manage through selective breeding as small RNAs are likely to be regulating patatin expression. Overall these findings can help not only to screen current varieties for performance and nutritional value under drought stress, but provide gene targets for further characterization as we seek to develop both nutritive and resilient crop varieties.

***Source***: Letitia Da Ros, Raed Elferjani, Raju Soolanayakanahally, Sateesh Kagale, Shankar Pahari, Manoj Kulkarni, Jazeem Wahab and Benoit Bizimungu (2020). Drought-induced regulatory cascades and their effects on the nutritional quality of developing potato tubers. *Genes* **2020**, *11*(8), 864: https://doi.org/10.3390/genes11080864

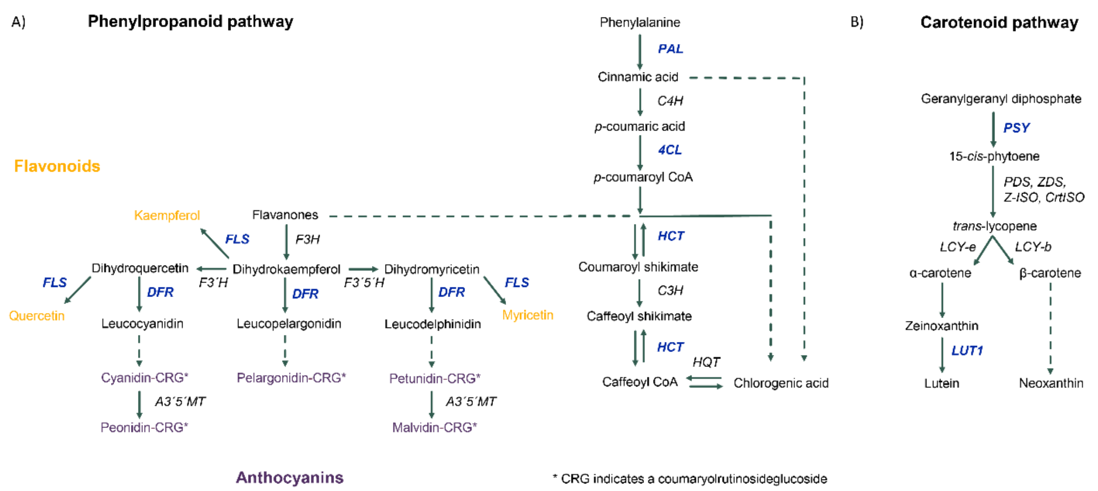



*Figure 2: Diagrams showing the key enzymes in the phenylpropanoid (A) and carotenoid (B) biosynthetic pathways. Genes that are significantly downregulated beyond cut-off values of 5 % FDR and a fold change greater than 4 are written in blue.*

## Exploring the Potential of Potato Cryogenics
## Technical site visit to the New Zealand Institute of Plant and Food Research (PFR)

Dr. Robin Browne* and Lisa Harkness**
Propagation Specialist,
* K.C. Irving Environmental Science Centre, Acadia University
** Agriculture and Agri-Food Canada, Fredericton Research and Development Centre (AAFC-FRDC)

In 2018, a research project was begun at Acadia University to develop a grapevine germplasm repository for the emerging grape and wine industry in Nova Scotia. The main objectives have been to develop methodologies to effectively utilize tissue culture and cryogenics for conserving valuable grapevine germplasm. Tissue culture is often utilized for conservation of clonal crops, but this method requires high labor input and can be susceptible to microbial contamination or somaclonal variation over time due to the need for repeated subculture on defined media rich in nutrients and growth enhancing compounds. The utilization of cryogenics, the long-term storage of tissues in liquid nitrogen, is being studied as a potentially viable low-cost complementary method of conserving valuable clonal germplasm. To date, over 40 grapevine cultivars has been tested in tissue culture, with successful recovery of several lines from cryogenic treatments demonstrated. This research continues in 2020.

Looking beyond our work with grapevine, potato is also being considered as an excellent candidate for future research and application of cryogenics in the conservation of germplasm, given the importance of the crop in this region. In addition to the potential for long term storage (cryopreservation), there is a growing body of evidence to indicate that this approach may also have benefits for eradication of viruses (cryotherapy).

Application of cryogenics in potato and other clonal crops has been limited in the past by technological issues associated with equipment requirements, low throughput of samples and inconsistent responses among genotypes. More recent advances in methods have opened the possibility of utilizing cryogenics as an integral strategy for clonal crop gene conservation. One of the more promising methods for general application is droplet vitrification. With this method, samples can be treated with sucrose loading and cryoprotectant solutions over a short period and then directly plunged into liquid nitrogen, where they can be kept indefinitely, and retrieved readily. One of the leaders in development and utilization of the droplet vitrification method for application with clonal crops (including potato) is The New Zealand Institute for Plant and Food Research (PFR).

In order to learn more about the technical aspects of the droplet vitrification method for cryogenics of grapevine and potato, former

Research Associate Lisa Harkness traveled to PFR on behalf of Acadia University. Recent findings at PFR have shown this method to be very effective with potato accessions. To date, about 150 of a total 220 lines have been tested, with a 40-100 % recovery overall. While at PFR from March to April 2019, Lisa met regularly with their Science Team Leader Dr. Ranjith Pathirana (Figure 1) and worked closely with Research Associate Liya Mathew (Figure 2). During her time at PFR, Lisa was able to learn the entire droplet vitrification process for potato cryopreservation (Figure 3).

Trials are now underway at Acadia University to test responses of three potato cultivars (‘Yukon Gold’, ‘Congo’ and ‘Shepody’) obtained from the National Potato Gene Resources repository in Fredericton. Results of these initial trials may prove helpful in determining the potential for applications of cryogenics to support ongoing potato conservation, research and breeding programs at Agriculture and Agri-Food Canada, Fredericton Research and Development Centre (AAFC-FRDC). The possibility of a collaborative project involving Acadia University, AAFC-FRDC and PFR is currently being explored.

*Figure 1: Dr. Ranjith Pathirana (L) Science Team Leader for the Germplasm Conservation Program at PFR, with Academic Visitor Lisa Harkness (R) from Acadia University.*

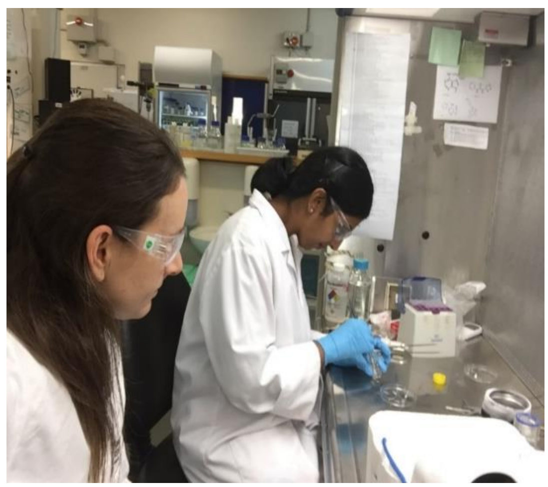


*Figure 2: Lisa Harkness (L) observing the droplet vitrification method, as demonstrated by Research Associate Liya Mathew (R) in the PFR cryogenics lab area.*

*Figure 3: The droplet vitrification method for potato: stock cultures as source of test material; shoot tips excised from stock cultures; loading and vitrification treatments; droplets of vitrification solution and shoot tips on foil strips; plunging foil strip with shoot tips into liquid nitrogen; recovery of shoot tips from liquid nitrogen, to re-establish shoot cultures.*

## Diversity analysis unravels resistance to common scab and offers avenues for improving genetic resistance in Canadian potato germplasm

Benoit Bizimungu
Fredericton Research and Development Centre, Fredericton, NB

Potato common scab is one of the most important diseases of potato worldwide (Figure 1). It is caused by a soil-born bacterial pathogen, *Streptomyces scabies*. A recent study recently focusing on Canadian potato germplasm unraveled the mechanisms of genetic resistance and provides avenues for breeding improved varieties. Currently, the most effective and desirable method to control it is through the development and use of varieties that exhibit natural resistance to the disease. The research team at the Fredericton RDC investigated the causes of genetic resistance in Canadian potato varieties. The reaction of 143 different potato varieties was evaluated in the presence of the scab disease in naturally infested soils, and an analysis of genetic variation in the DNA was conducted on the same varieties. Using computer analysis, regions on potato chromosomes 2, 4, and 12 that are associated with genetic resistance to common scab were identified. These three regions contribute 21%, 19% and 26% of the resistance to scab disease, respectively. The mode of action of genetic factors at each of the three chromosomal regions that contribute to resistance to common scab was also determined. These findings will provide accurate assessment of genetic potential of candidate varieties and enable efficient selection of new resistant varieties. The results were recently published in Potato Research (https://doi.org/10.1007/s11540-019-09437-w).

*Figure 1: Potato tuber showing severe symptoms of scab.*

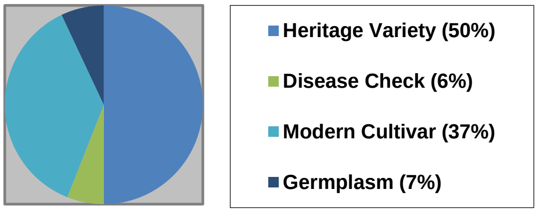
## Annual Report 2019

Canadian Potato Genetic Resources
Benoit Bizimungu, Tyler Nugent and Sylvia

### The Collection

### 1. Holdings

- The Canadian Potato Genetic Resources is a node of Plant Gene Resources Canada and holds 187 clones within its genebank. Of this total, 187 are maintained *in vitro*, and 71 accessions were grown for tuber production at our Benton Ridge Potato Breeding Substation, Benton, New Brunswick. A full listing of accessions may be found in the request form. The following chart illustrates the types of clones in each category.




## 2. New Accessions

- In 2019, there were 9 new introductions into the main collection available for distribution as of 2020. They are as follows:

  - AC Maple Gold

  Origin: Agriculture and Agri-Food Canada

  AC Maple Gold is a high-yielding oval/oblong, yellow-fleshed potato with an attractive appearance for the fresh market coupled with excellent French fry quality. The variety can be harvested early for French fry processing, but also maintains excellent fry quality during long-term storage. AC Maple Gold produces French fries with a uniform deep yellow color. (Source: Amer J of Potato Res 2001, 78:339-343).

  - BelJade

  Origin: Agriculture and Agri-Food Canada

  Dual use (Fresh/French Fry) variety, Medium vigour and mid-season maturity; with short oblong tubers with smooth white skin and flesh white.

  - Black Bull

  Origin: donated by Eric McCumber, N.B., Canada

  Black Bull was introduced into the collection in 2017, however, virus freeing has not been successful until now. 'Black Bull' is now available for requests and distribution.

  - Du Mont

  Origin: Agriculture and Agri-Food Canada

  Dual use (Chip and Fresh Market) variety with moderate plant vigour, mid-season maturity and moderate resistance to scab.

  - Impact

  Origin: Agriculture and Agri-Food Canada

  Fresh Market variety with oblong to long tubers with netted buff skin, flesh white and resistance to Fusarium dry rot.

  - Northstar

  Origin: Agriculture and Agri-Food Canada

  'Northstar' is a white-skinned, whiteflesh, mid-season maturing variety suitable for cold storage chipping. It is resistant to tuber late blight infection, moderately resistant to common scab, Verticillium wilt and Fusarium wilt, and moderately susceptible to foliar late blight. (Source: Amer J of Potato Res 2007, 84:437-445).

  - PR10-65-5LB

  Origin: donated by Privar Farm Inc.

  PR10-65-5LB selection originated from the cross between 'F02005' and 'Prospect'. It is resistant to late blight. The tubers are oblong, uniform, medium in size with shallow eyes, yellow flesh and a clean skin with good dormancy. The TGA content is 13.3mg/100g fresh weight. The plant is tall with a spreading growth habit and the leaves are medium green. The plant is late maturing. (source: Privar Farm Inc).

- PR10-65-8LB

Origin: donated by Privar Farm Inc.

PR10-65-8LB selection originated from the cross between 'F02005' and 'Prospect'. It is also resistant to late blight. The tubers are blocky with a dimple at the stem end, can be somewhat asymmetrical in shape with shallow eyes and a smooth, tan coloured skin and has a long dormancy. The flesh colour is yellow and the eating quality is very good. Tuber yields have been high, but under some growing conditions are prone to hollow heart. The plant growth is vigorous and late maturing (source: Privar Farm Inc).

- Starburst

Origin: Agriculture and Agri-Food Canada

Chip variety with high early season yield, low incidence of internal and external tuber defects, high specific gravity and moderate resistance to scab.

## 3. Evaluations

- Eighteen accessions were grown in an evaluation trial at Fredericton Potato Research and Development Centre. Two replications of fifteen hills were planted on June 17, 2019 and harvested on October 16, 2019. The varieties were as follows: 'Banana,' 'Carola,' 'CH72.03,' 'F61101,' 'Likely,' 'LRC 373-5,' 'LRC 4373-5b,' 'O'Higgins Blue,' 'O'Higgins Calico,' 'Prince Albert,' 'Siberian,' 'Superior,' and 'York.' The field evaluation plots are useful for morphological and agronomic evaluation, total glycoalkaloid (TGA) analysis, specific gravity measurement, and photographs documentation.

- In addition to the evaluation trial, twenty four accessions were grown in a single replication of ten hills at Fredericton Potato Research and Development Centre for demonstration purposes. The varieties are as follows: 'AC Brador,' 'Banana,' 'Beauty of Hebron,' 'Candy Cane,' 'Christmas Island Rose,' 'Congo,' 'Elmer's Blue,' 'Exploits,' 'F02018,' 'F66041,' 'F87084,' 'F88042,' 'Grand Falls,' 'Haida,' 'Keswick,' 'Lenape,' 'Lumpers,' 'Ozette,' 'OAC Ruby Gold,' 'Rideau,' 'Rochdale Gold – Doree,' 'Shepody,' 'White Rose,' and 'Yukon Gold.'

## 4. Management

- Passport data for 167 PGR accessions is available online at the Genetic Resources Information Network-Canadian Version (GRIN-CA). GRIN-CA may be accessed through the Plant Gene Resources of Canada website. New information will be posted on the new GRIN- GLOBAL portal.

- Disease testing was completed by Agricultural Certification Services located in Fredericton, NB in December. All new and existing *in vitro* accessions are tested on a five year rotational cycle. Forty clones were grown from tissue culture in the potato breeding greenhouse and tested for: PVA, PLRV, PotLV, PVS, PVX, PVY, and PSTV. All clones tested negative for associated diseases. In addition, all accessions in the grow out period were tested for tuber borne BRR disease. All samples tested negative for associated diseases. Extra mini-tubers are available for distribution in the spring of 2020.

- All *in vitro* clones were screened once during 2019 for bacterial and fungal contamination using Potato Dextrose Broth and Richardson's Broth. All clones currently in the Genebank are negative for bacterial and fungal contaminants.

- A total of 1262 micro-tubers were harvested from 180 of the genebank accessions in 2019. Approximately half of the micro-tubers were sent to AAFC Plant Gene Resources of Canada, located in Saskatoon, SK, in September 2019. The viability of the collection is protected by this remote storage location arrangement. Dallas Kessler, AAFC Plant Gene Resources of Canada, continues to monitor the micro-tubers in Saskatoon. The remaining micro-tubers are stored at the Fredericton Potato Research and Development Centre.

## 5. Distribution

- Accessions within Canadian Potato Gene Resources fall under The International Treaty on Plant Genetic Resources for Food and Agriculture, which requires recipients to sign a Standard Material Transfer Agreement (SMTA), before any material is transferred. Any and all material shall only be utilized, or conserved for training/education, research, and breeding purposes for food and agriculture. All request forms include the SMTA. For more information and assistance in determining whether your plans fall into this agreement visit: The International Treaty on Plant Genetic Resources website. By accepting shipment of the requested material, recipients accept all terms and conditions of the SMTA. Recipients names will be submitted to the Governing Body of the Treaty.
- Twenty-two requests for 211 clones were received in 2019. Clonal distribution categories are as follows: 234 clones of *in vitro* plantlets, 180 clones of field grown tubers, and 64 clones of greenhouse grown mini-tubers. 'Congo' was the most requested accession in 2019: followed by 'German Butterball,' 'Glenwood Red,' 'Six Weeks,' and 'Slovenian Crescent' – all having an equal number of requests.

**Distribution of Clones by Purpose – 2019**

| Purpose of Request | Number of requests | Clones | *In vitro* plantlets | Field tubers | Mini-tubers |
|---|---|---|---|---|---|
| Research | 19 | 466 | 228 | 180 | 58 |
| Teaching or Demonstration | 3 | 12 | 6 | 0 | 6 |
| Conservation | 0 | 0 | 0 | 0 | 0 |
| **Total** | **22** | **478** | **234** | **180** | **64** |

**Requests by Destination – 2019**

| Destination | Number of requests |
|---|---|
| Newfoundland and Labrador | 1 |
| British Columbia | 2 |
| New Brunswick | 6 |
| Quebec | 6 |
| Ontario | 6 |
| Saskatchewan | 1 |
| USA | 1 |
| **Total** | **22** |

**Five-Year Compilation of Clone Distribution for Potato Gene Resources 2015-2019**

| Year | Research | Education | Conservation | Total | Field tubers or mini-tubers | *In vitro* plantlets | Total |
|---|---|---|---|---|---|---|---|
| 2015 | 14 | 1 | 7 | 22 | 360 | 186 | 546 |
| 2016 | 23 | 4 | 5 | 32 | 826 | 195 | 1021 |
| 2017 | 15 | 3 | 0 | 18 | 414 | 98 | 512 |
| 2018 | 20 | 3 | 0 | 23 | 335 | 50 | 385 |
| 2019 | 19 | 3 | 0 | 22 | 244 | 234 | 478 |
| **Total** | **91** | **14** | **12** | **117** | **2179** | **763** | **2942** |

## Repository Items of Interest

### Communication

• In addition to the requests for clones, many requests for information about the genebank, the availability of clones, clone descriptions and pedigrees, and techniques for handling *in vitro* material were received throughout 2019.

• The annual Potato Gene Resources newsletter has a distribution list of approximately 300 recipients.

• The current newsletter and several back issues may be accessed on the Weekly Checklist of Government of Canada Publications.

## Miscellaneous Information

### Donor Agreement

• Donors wishing to provide plant material to Agriculture and Agri-Food Canada (AAFC) for the purpose of research, conservation and distribution by Plant Gene Resources of Canada must now complete a "donor agreement". Decisions on accepting material into the Canadian Potato genebank are up to the discretion of the curator, Dr. Benoit Bizimungu (Benoit.Bizimungu@canada.ca).

## Visitors

• January 23, 2019 – Staff from the New Brunswick Plant Propagation Centre toured the potato genebank.

*Research Scientist and genebank curator Dr. Benoit Bizimungu (center) leading tour of Potato Genetic Resources genebank.*

• April 23, 2019 – The Minister of Agriculture and Agri-Food, Honourable Marie-Claude Bibeau visited the Fredericton Research and Development centre and toured the potato genebank.

*Research Scientist and genebank curator Dr. Benoit Bizimungu (Left) explaining the genetic diversity maintained in the genebank collection.*

• July 17, 2019 – The Assistant Deputy Minister, Dr. Gilles Saindon visited the Fredericton Research and Development centre and toured the potato genebank.

*Research Scientist and genebank curator Dr. Benoit Bizimungu (left) leading tour of Potato Genetic Resources genebank, with The Assistant Deputy Minister Dr Gilles Saindon (center) and Bonnie Robertson, Acting Associate Director, Research, Development and Technology Transfer (right).*

• October 18, 2019 – The Deputy Minister of Agriculture and Agri-Food, Chris Forbes visited the Fredericton Research and Development centre.

*Acting Potato Genebank technician Connor Johnsen (centre) showing material he is working on to Deputy Minister Chris Forbes (right) and Mark Grimmett, Acting Director, Research, Development and Technology Transfer (left).*

## Fredericton Research and Development Centre Website

• The Fredericton Research and Development Centre is custodian of the Canadian Potato Genetic Resources. The Fredericton Research and Development Centre website offers an overview of the Centre's mandate, resources and achievements along with research studies being conducted at the Centre and the staff associated with those studies.

## Plant Gene Resources of Canada

• Plant Gene Resources of Canada (PGRC), the national Canadian genebank, preserves, characterizes and distributes plant genetic resources for food and agriculture. PGRC is based on collaboration between AAFC Research Centres and people dedicated to preserving the genetic diversity of crop plants and their wild relatives. PGRC plays a significant part of AAFC's commitment to the Canadian Biodiversity Strategy in response to the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources.

• The Plant Gene Resources of Canada (PGRC) website includes information on the PGRC multi-nodal system of germplasm conservation in Canada and allows searching for germplasm information on the Genetic Resources Information Network-Canadian version (GRIN-CA).

## The Genebank and the Seed Potato System

• The Canadian Potato Genetic Resources provides *in vitro* plantlets and greenhouse or field tubers for breeding, research and heritage preservation. While extensively tested for freedom from disease, the plantlets and tubers distributed are produced outside the Canadian Seed Certification System and are not eligible for certification.

• The Canadian Seed Potato Certification System operates under the *Seeds Act* and its regulations. Certification begins with tested plantlets established *in vitro* in a facility accredited for this task by the Canadian Food Inspection Agency (CFIA). The plantlets are used to produce greenhouse tubers which then go to the field in a limited generation system, at each step meeting strict standards specified in the regulations. More information on potato seed certification can be found at the CFIA website.

## Help us Reduce our Paper Usage

The Potato Gene Resources Newsletter is available as an electronic version. If you are still receiving a paper version and wish to receive future Newsletters by e-mail, in pdf (portable document format), please send your e-mail address to: Sylvia.Soucy@canada.ca. We will continue to send the printed Newsletter to those who do not ask to receive it electronically. Maintaining contact with you is important.

## Curator's Note

I would like to acknowledge the contribution of Mr. Tyler Nugent and Mr. Connor Johnsen who successfully acted in the capacity of the potato gene resources technician while to Ms. Sylvia Soucy was on maternity. Their efforts and dedication ensured the continuity of the service provided to genebank users in Canada and around the world, and supported on-going research to preserve and enhance to the Canadian potato genetic resources .

**TO RECEIVE THE NEWSLETTER, PLEASE CONTACT:**

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Potato Gene Resources

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