POTATO GENE RESOURCES

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Table of Contents

Genetic Resources and the Associated Information in the Three Genebanks of the Canadian National Plant Germplasm System

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The faithful readers of the annual Potato Gene Resources Newsletter will know that Agriculture and Agri Food Canada (AAFC) has three genebanks: (1) the Plant Gene Resources of Canada (PGRC) at Saskatoon (SK) for seed germplasm; (2) the Canadian Clonal Genebank (CCGB) at Harrow (ON) for fruit germplasm; and (3) the Canadian Potato Gene Resources (CPGR) at Fredericton (NB) for potato germplasm. These genebanks are part of the Science and Technology Branch of AAFC.

The two main deliverables of these genebanks are:

- Viable disease-free germplasm of cultivated plants and crop wild relatives important to Canada
- Providing and generating relevant information on its germplasm holdings

The holdings of all three genebanks amount to more than 120,000 accessions covering close to 1000 botanical species of plant genetic resources for food and agriculture. About 70% of the germplasm holdings are cereal and crop wild relatives of cereals. The key challenge is to maintain the living collections and genetic diversity of crop plants and crop wild relatives, a lot of which is globally unique material. From 2002 to 2022 a total of 141,649 genebank accessions were distributed to clients in 65 countries around the world for use in research, breeding or education.

While the living material is unique and valuable, it is absolutely essential to also have the information that is associated with this material well preserved and available. What use is a bag of seeds if you do not know at least the species name including the scientific name, the cultivar name, the place of origin, the year it was collected or bred, the name of the collector or provider of the germplasm? This is all essential **Passport Data**. According to the International Treaty on Plant Genetic Resources for Food and Agriculture (https://www.fao.org/plant-treaty/en/) all national gene banks around the world committed to provide not only the genetic material but also the associated passport data. In addition to passport data, there is also **Characterization Data** describing basic features, which may include seed colour, seed size, flower colour, leaf shape, plant height, and maturity date. Ideally, characterization data is supported by stored images (**Image Data**) of the genebank accessions. Each plant species has its specific set of characterization data based on standardized descriptor lists used by genebanks around the world. A third set of data called **Evaluation Data** is generated by experts assessing features such as disease resistances and seed oil content or fatty acid composition. And then there is a fourth set, the **Molecular Characterization Data** on specific molecular markers or describing the DNA sequence of the genome of the plant material, **Genetic Sequence Data.**

In addition, the genebanks also have **Management Data**, describing seed viability, inventory information, information on various seed lots of the same accessions, information on the placement of seed envelopes on shelves or in storage vaults, and information on back-up storage in other locations or at the Svalbard Global Seed Vault. This management data is essential for the genebanks to operate efficiently

Figure 1. *National genebanks and the genebanks at International Agricultural Research Centres implementing or evaluating GRIN-Global as a genebank database management system (Source: [https://www.grin-global.org/).](https://www.grin-global.org/))*

but in contrast to the other data sets it is not by default accessible to the public.

With the exception of the molecular data, the three Canadian genebanks collect, generate, document, handle and distribute passport, characterization and evaluation data, as well as large sets of image files. Molecular data is generated by scientists using genebank germplasm and efforts are in many countries underway to also make this data accessible. Measured in bytes the volume of molecular data is immense compared to the other data sets, which poses major challenges in handling this data. The images also require a lot of data storage capacity. The more information associated with the material that is available, the better the rational conservation and utilization of the unique diversity that can be achieved. However some information, such as the passport data is absolutely essential.

A very specialized genebank database management system called GRIN (Genetic Resources Information Network) that was initially developed by the United States Department of Agriculture (USDA) in the 1980s has been used by PGRC, CCGB and CPGR for more than 20 years. In 2011, an update to the GRIN-Global was developed by the USDA in cooperation with the Global Crop Diversity Trust and Bioversity International. Since 2019 this update is actively used by the Canadian genebanks. GRIN-Global is used by many national genebanks and the large genebanks at the International Agricultural Research Centres (Figure 1). A GRIN-Global website has ample information on this (https://www.grin-global.org/).

With the help of the Information Systems Branch (ISB) of AAFC and a dedicated full time staff member of ISB located at the Saskatoon location of PGRC we at PGRC are in the final stage to update all information associated with the germplasm collections of the three Canadian

genebanks. The switch to the modern GRIN-Global-CA resulted in losing some query services for genebank clients, but active work is ongoing to regain not only full functionality but also to make full use of the improvements GRIN-Global offers to provide client service.

For external users' passport, characterization and evaluation data will be accessible. The staff members at the three genebank locations are actively working on updating the information in the Canadian GRIN-Global-CA database which can be accessed from the PGRC website (https://agriculture.canada.ca/en/science/agriculture-and-agri-food-research-centres/plant-gene-resources-canada). Images will also be made accessible. Many errors in existing data need corrections and there are large amounts of characterization and evaluation data that needs to be uploaded. The management data needs steady attention, because seed increase, germplasm characterizations in fields and greenhouses, adding new germplasm and viability testing are ongoing genebank activities.

In October and November 2023 a training on GRIN-Global for genebank staff in Canada, Mexico and the US was organized by the Task Force on Genetic Resources of the PROCINORTE program (Genetic Resources - (procinorte.net)). The training included six on-line sessions of 1.5 hours length each. It was led by Marty Reisinger from the USDA. The training sessions were recorded and made accessible on-line on the GRIN-Global website (https://www.grin-global.org/intro_to_GG_procinorte.htm). The objective to introduce all participants into core-functions of the GRIN-Global genebank database system was fully achieved.

The impact will be great as GRIN-Global facilitates handling passport, characterization, evaluation and management data and moreover provides data accesses to global genebank clients. Transparency and information-flow is supported, as well as the hands-on management of the collections. This will contribute to biodiversity conservation and the global efforts towards a more sustainable agricultural sector by supporting efficient conservation and sustainable use of the biodiversity of cultivated plants and their crop wild relatives. This has great impact for plant breeding, the agricultural sector and the Canadian biodiversity related objectives arising from agreements such as the International Treaty on Plant Genetic Resources for Food and Agriculture (https://www.fao.org/plant-treaty/en/) and the Convention on Biological Diversity (https://www.cbd.int/).

What Does It Mean to Be a (Potato) Seed Saver?

Maddison MacDonald

Seed Savers Exchange, Decorah, Iowa

At Seed Savers Exchange (SSE; see https://seedsavers.org), we steward thousands of varieties from around the world with stewardship history in the United States. These varieties come from different cultural backgrounds and have intricate journeys and evolving stories. Nothing about a seed is finite, and just by preserving one heirloom, we save a multitude of stories, support cultures near and far, and, most importantly, preserve the future of food. By saving seeds, we are providing the basis for adaptation and breeding grounds for even more varieties, many of which will be necessary to combat climate change issues. Additionally, we are preserving biodiversity to rival the monocultural agricultural system that predominates today.

My main goal as the potato tissue culture technician at SSE is to get rare potato varieties back into the hands of individuals who will steward them into the future, reflecting our goal of "keeping heirloom seeds in our gardens and on our tables." As an organization, SSE works hard to keep our collection "living," as public engagement is an integral part of our mission. Providing open access to our accessions, including virus-free potatoes and scion from our historic apple orchards, is one of the many ways we try to actively engage with diverse communities to help preserve varieties in our collection and continue their stewardship. We do this through the Exchange, which is essentially a large online seed swap that allows not only SSE but also gardeners from around the country to offer thousands of heirloom and open-pollinated seeds that have been grown and saved. In 2024, SSE is offering 50 different potato varieties on the Exchange, both tuber and tissue culture, surmounting the number listed in previous years.

We have 177 virus free varieties in our potato gene bank, but in total we have just under 700 different varieties. In order for a variety to be eligible for the Exchange or to be grown out on our farm, they must be virus free. Virus eradication is an important piece of potato stewardship, but it takes at least one year of treatment before a plantlet is virus free. Due to this long timeline, we actively work to source virus free material to replace accessions that are heavily infected with virus to continue to grow the accessibility of our potato gene bank. In August of 2023, we worked closely with Agriculture and Agri-Food Canada's Canadian Potato Gene Resources (CPGR) lab in Fredericton, NB to replace 40 infected potato varieties with virus free material. Many of these varieties were donated to SSE back in 2008-2009, so replacing the older plantlets with new, virus free germplasm was a huge accomplishment, shaving years off of the timeline for a virus free incubator. All 40 accessions are now accessible to the public through the Exchange, some of which are Arran Victory, British Columbia Blue, Cain's Irish Rocks, Siberian, and so many more! Along with these 40 new accessions, we grew 10 varieties out on the farm that are also on the Exchange. Purple Peruvian, Garnet Chili, Blossom, Bodega Red, and Snowdrift are some of the tuber varieties we are offering for 2024 (see Figure 1).

Figure 1. This photo shows the potatoes in our root cellar that were harvested for the Exchange. (2023)

Potato tissue cultures will also be offered for trialing in our Community Science ADAPT program for the first time in 2024. Through ADAPT, participants in the U.S and Canada trial varieties from the SSE seed bank in their own gardens and send us feedback on their performance. This information helps us better

understand the adaptability of these varieties in different environments and ultimately guides our selection process for new introductions into the Seed Savers Exchange catalog. This program continues to forge strong relationships by providing engagement through a platform called SeedLinked that builds a fortified community around seed.

Humans have been saving seeds for millennia, especially potato tubers and seeds. As can be seen in Figure 2, potatoes originated in the Andes thousands of years ago and today remain the fourth most important food crop in the world (Agricultural Marketing Resource Center, 2021). When Columbus came over to the “New World" in 1492 Europeans were still eating foods primarily made of grain, cabbage, or peas. It was in 1535 that Europeans first reported seeing potatoes, which they believed were some sort of truffle or underground fungus. *Tartufulo*, the Italian word for truffle, is one of the ways “tuber” became more popular. You can see this influence in other languages as well. For example, the name for potato in German is *Kartoffel*, meaning truffle (Popenoe et al., 1989). The story of the potato certainly has an intricate beginning, and the continued stewardship of these early varieties paved the way for modern-day cultivars.

Not only did Europeans in the 16th century misunderstand what the potato was, but that misunderstanding also generated fear across the continent. To Europeans of this era, the potato was to be avoided at all costs. Since the potato is not mentioned in the Bible, many considered it “evil” and unfit for human consumption. French experts were even convinced that the potato was going to destroy their soil. Botanists everywhere, including Linnaeus, generated a lot of suspicion around the potato as it is related to “Devil’s

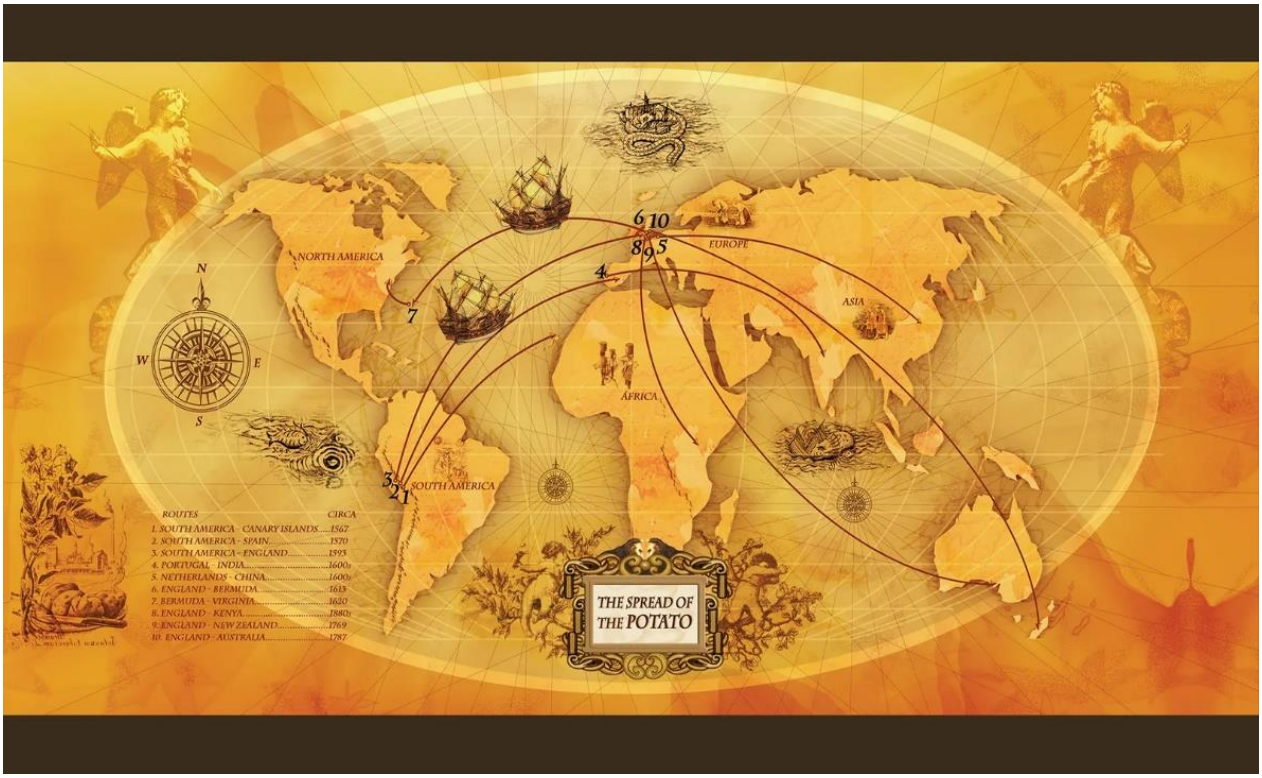

Figure 2. This map depicts the spread of the potato from its origin in the Andes. (International Potato Center, n.d.)

Herb," the deadly nightshade. And if that wasn't enough of a deterrent, residents of several countries thought the potato was a toxic aphrodisiac, fearing that it would cause humankind to go mad with lust (Popenoe et al., 1989). However, despite all of these misconceptions, not to mention the Great Famine in the 1800s—when potato crops in Ireland were infected by blight—the potato is still here, and thankfully thriving.

The survival of the potato is all due to the work of dedicated seed savers over the years. Without the continued and culturally diverse way of saving seeds, we may have never seen the potato today. During the 8,000 years of potato cultivation in the Andes, farmers were able to select tubers or seeds from their strongest, best performing plants and replant them next season. By doing this, they were also able to feed their communities despite the multiple microenvironments throughout South America. This longstanding practice of selection is what created the thousands of different types of potato, a process that is still practiced today around the world. Unfortunately, even back when potato saving began, many varieties were moved aside for more commercially apt or more "modern" varieties (Popenoe et al., 1989). This has led to the disappearance of some of the oldest varieties, which is why we in our current time must focus on preservation even more so.

The question may still stand: What does it mean to be a potato seed saver? In January 2023, a gentleman from Ohio who has been an SSE member since 1997 reached out to our preservation director inquiring about a specific potato, 'Brigus.' He had been searching for this variety high and low for years, without success. "It's my favorite potato," he explained in his email, "I hope you grow them out because I cannot find them anywhere." As it turned out, SSE did have the variety in its collection, and we were able to grow it out this year.

Watching 'Brigus' grow was a beautiful experience, not only because of its thick foliage and deep purple stems but also because I was now able to share this variety with someone who cherishes it. Passing 'Brigus' on to this gentleman helps to ensure the survival of this variety as it is now in the backyard of someone who will steward it and, in turn, share it with others (Figure 3). 'Brigus' was developed by Kenneth G. Proudfoot for Agriculture Canada at the St. John's West Research Station in Newfoundland from a cross between "G64-124-5p" and "SJ62-26-14" in 1971. While the story of the 'Brigus' potato may seem small, it is by no means unimportant. By continuing the journey of 'Brigus,' we have strengthened Brigus's story and given it the opportunity to spread to other communities, generate more stewardship stories, and become yet another success in our concerted effort to help preserve biodiversity.

Figure 3. This photo shows 10 pounds of the 'Brigus' potato ready for shipment to Ohio. (2023)

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British Columbia German Butterball Potato: Another Unique Potato Variety in Canada

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Potato diversity is a key element in ensuring food sustainability during a time of climate change (see website http://heritagepotato.ca/). The Crop-Climate project (see previous) has investigated heritage varieties across Canada and especially in British Columbia under varied climatic conditions. The project has submitted several varieties to the Canadian Potato Gene Resources Collection that were made available to the project over the years. A couple of these have turned out to be distinctive and unique [See Gene Resources newsletter issues for articles on varieties "Likely" (Hebda and Huff 2013) and "Icelandic Red" (Hebda et al. 2023)]. In this contribution, we describe a German yellow variety provisionally called British Columbia (BC) German Butterball that superficially resembles other similar tubers but on genetic investigation turns out to be unique in Canada. Furthermore, it reliably produces a high yield of tubers of a large size and high quality. We also include a note from another BC interior variety mistakenly named "Likely" investigated at the same time.

In this article, we describe for the first time the characteristics and phenology of BC German Butterball. We further report results of Single Nucleotide Polymorphism (SNP) analysis that demonstrate its unique genetic placement and relationship to other related varieties.

Tubers of the variety were provided to Richard Hebda by Karen Johnson in 2015. She and her husband Tom Puckett live and grow potatoes in 100 Mile House, in the central interior of British Columbia. Karen obtained it from a local acquaintance who got it from a friend in White Rock, BC 15 years ago. The White Rock source simply knew it as German Butterball, originally from Germany. Karen and Tom consider this their best overall potato variety.

BC German Butterball looks like a typical

German yellow variety. In our trials, it produces well, with large, blocky tubers (Figure 1). This variety grows into robust well-branched plants (Figure 2) with white flowers. Tubers are produced mostly beneath the crown with few long tuber-bearing stolons. The potatoes occur relatively deep in the soil, 30-40 cm down beneath the normally hilled surface. Tubers are pale yellow with thin mostly smooth skin and pale yellow flesh (Figure 3). There are relatively few eyes. When cooked the texture is slightly waxy.

In 2022, we recorded the growth and development on Vancouver Island's Saanich Peninsula during a cool and moist spring and early summer. Medium-sized tubers were planted whole on May 9. They had fat, large, short sprouts. All 10 plants emerged by June 10 and had strong shoots. By July 1 plants were in full bloom with white flowers persisting for three weeks. By July 8 bushes were 50-70 cm tall and branching strongly. Plants continued to grow robustly until July 21, but by July 29 they were beginning to droop and yellow slightly. Between this time and August 18, plants had fully yellowed and turned mostly brown. Tubers were not harvested until mid October, but were assumed to be ready in mid to late July, approximately 95 to 100 days after planting. Plants were never watered in 2022. The yield from two plants that year was an astonishing 3.5kg, or 1.75 kg per plant, much greater than typical for other heritage varieties we have grown in trials. These do not often yield more than 0.5 kg per plant without regular watering.

Figure 1. Typical yield from a single plant of British Columbia German Butterball potato grown in 2023 on the Saanich Peninsula. B.C. Photo Richard Hebda, October 2023

Figure 2. Leaves and stem of British Columbia German Butterball potato grown in a greenhouse, 2023. Photo: Benoit Bizimungu

Figure 3. Freshly dug British Columbia German Butterball tubers showing size, shape and colour. Photo: Benoit Bizimungu

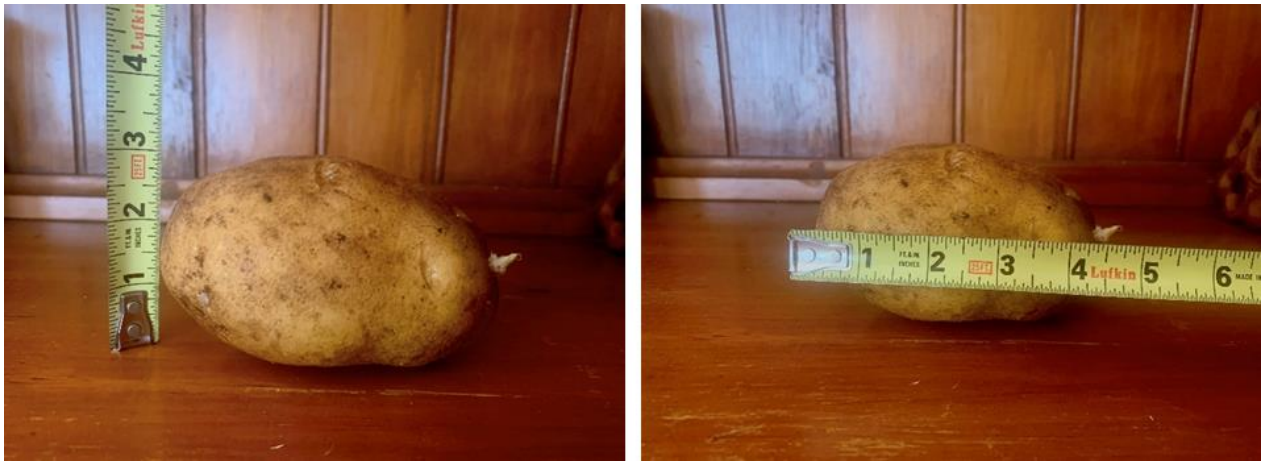

Figure 4. Length and width of a single tuber from Karen Johnson and Tom Puckett's farm, 2023. (Photo: Karen Johnson)

In 2023, an extreme drought year with a warm spring, but June frosts, a row of 10 tubers was planted 0.50 cm apart and 1m from adjacent rows in silty fine sand. The row produced 12 kg of well-formed large tubers (1.2kg per plant) again a substantial yield for a heritage variety. Tubers were mostly large, clean and well-formed. A typical large tuber weighed from 0.25 to 0.28 kg. Tubers were planted on May 5th and harvested on October 3rd at which time the bush had long dried. Watering during this extremely dry year was limited to three soaker hose deliveries of about 1 hour each. There were aphids early in growth, but these were not treated.

In the same year in the much more continental climate of BC's central Interior, Karen

Johnson and Tom Puckett reported a yield of 100lbs (45.5 kg) in a 3m x 1.2 m raised bed from 40 tubers. The potatoes got steady early morning watering and the soil was augmented with activated charcoal, alpaca manure, compost, azomite and zeolite. The planting surface was covered in a 5-10cm layer of trampled hay without any manure. Moderately large tubers (not the largest) exceeded 500 gm in weight (Figures 4, 5).

Figure 5. One tuber weighed in at 18.3 ounces, or just under 520 grams from K. Johnson and T. Puckett's garden. (Photo: Karen Johnson)

Genetic data and relationship to other varieties

Using a set of high-quality genome-wide single nucleotide polymorphism (SNP) markers (Douches et al 2014), the BC German Butterball variety was found to be genetically close to Corne de Bélier, another variety recently acquired by Canadian Potato Gene Resources Collection (Figure 6: dendrogram, Figure 7: Corne de Bélier). Both varieties also showed close genetic similarity with two other heirloom varieties maintained in the Canadian Potato Gene Resources Collection, Mrs. Moehrle's Yellow Fleshed (Figure 8) and traditional German Butterball (Figure 9).

Plants of German Butterball grown in the greenhouse at Fredericton in 2023 had white flowers, similar to those of Mrs. Moehrle's Yellow Fleshed but showed moderate to strong stem pigmentation in the greenhouse (see Figure 2). Tubers were oval to oblong with yellow skin and flesh (see Figure 3),

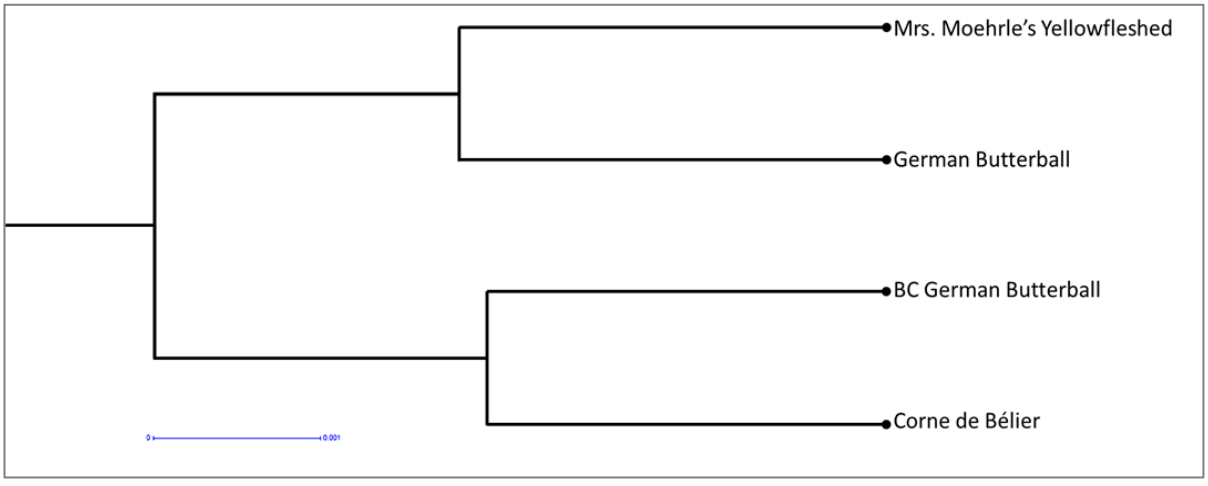

Figure 6. Dendrogram of SNP showing the relationship between the BC German Butterball and three closely related genetic clones: Mrs. Moehrle's Yellow Fleshed, German Butterball, and Corne de Bélier.

Figure 7. Tubers of Corne de Bélier (greenhouse, 2023). Photo: Benoit Bizimungu

Figure 8. Mrs. Moehrle's Yellow Fleshed seed potatoes ready for planting, inset of cross section on harvest. Photos: Chris Wooding 2013.

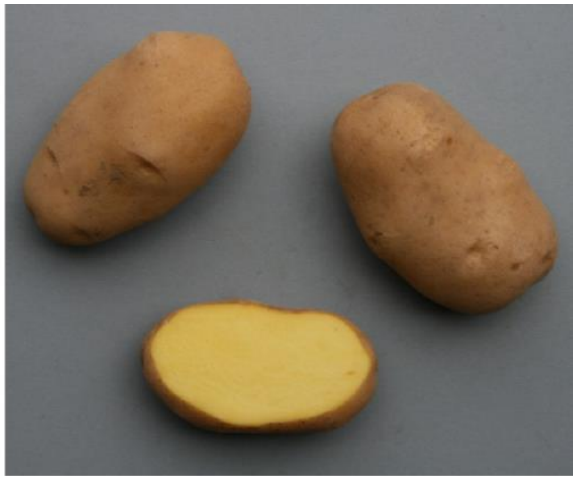

Figure 9. Tubers of true German Butterball (field grown, 2023). Photo: Benoit Bizimungu

similar to Mrs. Moehrle's Yellow Fleshed, true German Butterball and Corne de Bélier (Figures 7-9).

The Mystery of the "Likely Legend"; Solved by DNA Fingerprinting

Karen and Tom contributed clones of both the BC German Butterball and Likely varieties to the Crop-Climate Project. From some of the tiny "Likely" tubers grew pink fingerlings, similar in shape and size to the more tan-skinned "Likely" potatoes. We grew these out under the name 'Likely Legend' and observed them to grow more vigorously with larger tubers than the true "Likely". Suspecting a new and exciting variety, we sent some to the Canadian Potato Gene Resources collection for further testing. There, they underwent the same genetic SNP analysis. What we found was that these potatoes were indistinguishable from the heirloom varieties Pink Fir Apple and Rose Finn Apple, and closely related to the well-known Banana fingerling (Figure 10).

With thousands of varieties of potatoes, it can be hard to distinguish between similar varieties based just on their morphology. Using a type of DNA 'fingerprinting', such as the SNP analysis performed here, can be used to visualize the genetic distance between different samples through a tree-like diagram, called a dendrogram. Groupings in a dendrogram are represented by branches of similar groups. The length and height of the lines represents the similarity/distance between the groups or individuals.
The mystery of the "Likely Legend" was solved through SNP analysis (Figure 11). A

Figure 10. "Likely Legend" tubers grown in Saanich, BC 2023. Photo: Richard Hebda

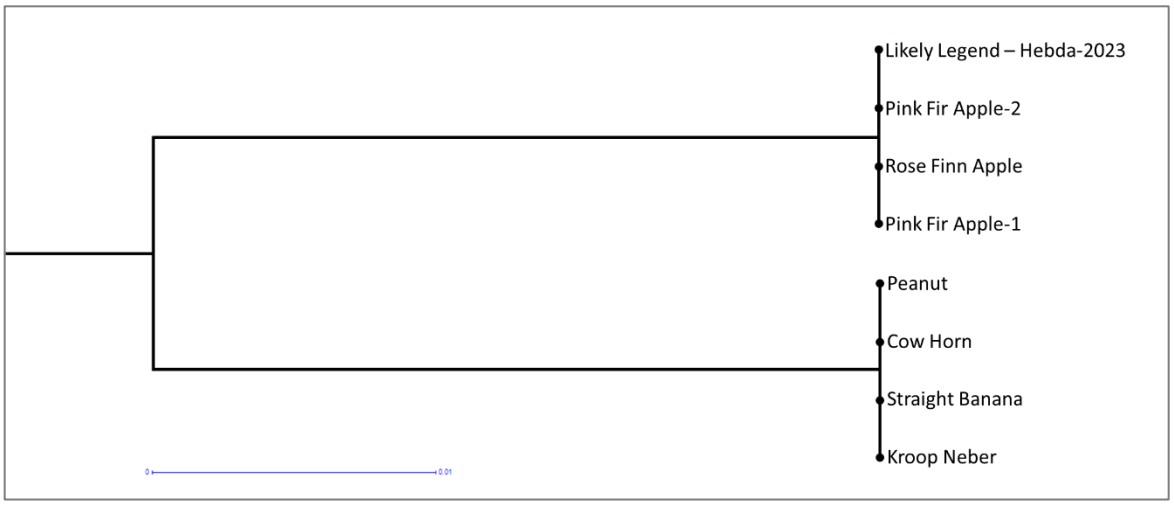

Figure 11. Dendrogram of SNP showing the relationship between the 'Likely Legend' and other accessions from the Canadian Potato Gene Resources

tiny tuber of Pink Fir Apple had been accidentally included with "Likely" tubers. The "Potato House" in 100 Mile House, BC, the source of the real Likely tubers had long grown several heirloom varieties and Pink Fir Apple appeared to have been mixed into the lot. Karen and Tom had indeed noted that among the standard Likely tubers they had peculiar pink knobbly fingerlings. These rogues they tried to eliminate with each harvest.

The gene pool of Canadian Heritage potatoes is very deep. It contains genetically unique and exceptionally productive varieties. We are grateful to Karen Johnson, Tom Puckett, and all the other heritage potato growers who keep this diversity and the stories that go along with them alive. Continued trials and genetic investigations are vital to uncovering the enormous potential of our national diversity of potatoes.

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Heritage Potato Varieties from the Antiplano Featured on Postage Stamps

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The potato was domesticated by the Aymara and Quechua Indian civilizations in the Altiplano (Andean highlands) of South America in the area which today is known as Peru and Bolivia. Along the shores of Lake Titicaca there are still raised beds (Figure 1) like those which more than two millennia ago served as the "cradle" of the potato. Many heritage varieties which were developed many centuries ago are still being grown today in the above-mentioned highlands. Several thousand heritage varieties are being maintained in the Potato Park in the Sacred Valley of the Incas near Cuzco, Peru (Wong and Argumedo, 2011).

Potatoes, including heritage potato varieties, have been and continue to be featured on postage stamps of many countries (De Jong, Van Loon and Heijboer, 2022). One of the reasons for this is because the potato is the world's third largest food crop and is held in high esteem around the world. In some cases, the variety's name is also shown on the stamp whereas in other cases the stamps may simply show the variety.

When the Food and Agriculture Organization (F.A.O.) declared 2008 as the International Year of the Potato, Peru issued a beautiful stamp (Figure 2), very appropriately entitled *Tesoro enterrado* ("Buried treasure"). Other stamps issued by Peru include a picture of the terraces for growing crops such as corn and potatoes in the Sacred Valley (Figure 3). Potatoes have also been featured in ceramic pottery such as the one shown on a stamp from Peru which features a potato tuber (Figure 4) from the Mochica period (app. 100-700 AD).

Figure 1. Raised beds on the shores of Lake Titicaca. Source: Francisco J. Morales, CIAT, Colombia.

Figure 2. Peruvian stamp celebrating the International Year of the Potato.

Figure 3. Stamp image of crops grown on the terraces in the Sacred Valley of Peru.

Figure 4. Stamp of Peruvian ceramic pottery featuring the potato.

Also in 2008, celebrating the International Year of the Potato, Bolivia issued four different stamps with heirloom varieties. Each of these Bolivian stamps features a picture and a name of a different variety. There are several aspects worth noting just from these four stamps:

a. The great diversity for shape and colour among these heritage varieties testifies to the sharp eye and skillful selection of the first potato farmers.
b. In their area of domestication potatoes were, in addition to being used as food, also used in dyeing clothes and in (religious) ceremonies.
c. After the Aymara were conquered by the Incas, the Aymara language was eventually replaced by Quechua but in some locations, Aymara continues to be used. Several names of potato varieties are still Aymara while others are Quechua.
d. The Aymara already had a "primitive" binomial system of taxonomy which is based on the use of a descriptive word for the variety, with the addition of a modifying adjective (often a colour name) as explained below.
e. "Luk'i Negra" (Figure 5) means "Black potato which resists frost."
f. "Sani Imilla" (Figure 6) is part of a group of Aymara varieties where "Imilla" means girl or unmarried woman. The meaning of "Sani" is not clear to us.
g. "Saq'ampaya" (Figure 7) is an Aymara variety which means "Long fruit." It has been reported to be very suitable for the preparation of chuño (De Jong, 2023).
h. "Puka Waych'a" (Figure 8) is still a popular Quechua variety which means "Red face." Some promotional literature indicates that it has deep eyes, red skin, white flesh and can be grown in both low and high altitudes and in all types of soil. It is reportedly tolerant to drought and potato cyst nematodes.

Figure 5. Bolivian stamp, "Luk'i Negra."

Figure 6. Bolivian stamp, "Sani Imilla."

Figure 7. Bolivian stamp, "Saq'ampaya."

Figure 8. Bolivian stamp, "Puka Waych'a."

The world is greatly indebted to the Andean farmers who not only domesticated the potato but also made selections for various end uses. In addition, they developed a system of taxonomy which enabled them to describe the differences between their selections. The taxonomy of the Aymara and Quechua civilizations predated the famous Swedish botanist Linnaeus (1707-1778), the "father of modern taxonomy," by several millennia!

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Annual Report 2023

The Canadian Potato Genetic Resources
Stephanie Browne and Benoit Bizimungu

THE COLLECTION

1. Holdings

Canadian Potato Gene Resources (CPGR) is a specialized node of Plant Gene Resources Canada (PGRC) and currently maintains a diverse collection of over 200 potato clone varieties (Figure 1). All clones are maintained as *in vitro* tissue culture with a substantial number of these also grown in the field for seed multiplication or maintenance at the Benton Ridge Potato Breeding Substation in Benton, New Brunswick. A full listing of accessions is provided with the request form that is accessible by contacting us.

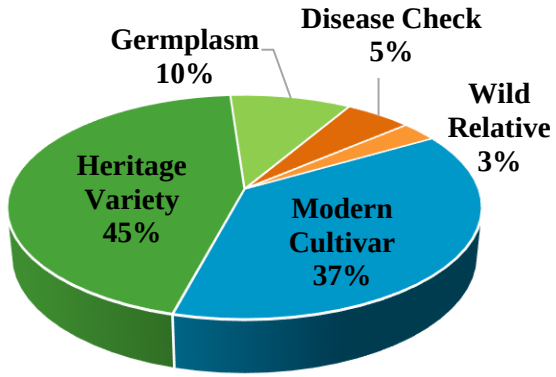


Figure 1. Diversity of potato varieties in the CPGR Public Collection

2. New Accessions

In 2023, several new accessions were added to the genebank collection including the collection's first clones in our newest Wild Relative (WR) category.

1. PL-4 (CIP596131.4) [CN# 124025]: Germplasm

Haploid inducer line developed by the International Potato Center (CIP, Lima, Perú) and introduced from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. It was selected from the cross between 'IVP 35' × 'IVP 101' for its highest haploid inducer ability when crossed with tetraploid (4*x*) breeding lines and features a high degree of flowering, shedding and pollen viability. [Source: https://doi.org/10.1007/978-3-030-28683-5)].

2. DPM-AA9 [CN# 124026]: Wild Relative

A genotype selected from botanical seeds of *Solanum acaule* accession PI 498202 obtained from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal).

3. DPM-S15 [CN# 124027]: Wild Relative

A genotype selected from botanical seeds of *Solanum gandarillasii* accession PI 545864 obtained from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal). It carries the S15 self-incompatibility allele [Sources: E. Lafleur 2009 (Thesis-U Montreal); J. Soulard 2014 (Thesis-U Montreal); Liu B et al (2009). PLoSONE 4(6):e5774.doi:10.1371/journal.pone.0005774]

4. DPM-S7 [CN# 124028]: Wild Relative

A genotype selected from botanical seeds of *Solanum pinnatisectum* accession PI 275236 obtained from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal). It carries the S7 self-incompatibility allele. [Sources: E. Lafleur

2009 (Thesis-U Montreal); J. Soulard 2014 (Thesis-U Montreal); Liu B et al (2009). PLoSONE 4(6):e5774.doi:10.1371/journal.pone.0005774]

5. DPM-S12 [CN# 124029]: Wild Relative

A genotype selected from botanical seeds of *Solanum tarijense (berthaultii)* accession PI 473243 obtained from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal). It carries the S12 self-incompatibility allele. [Sources: E. Lafleur 2009 (Thesis-U Montreal); J. Soulard 2014 (Thesis-U Montreal); Liu B et al. (2009). PLoSONE 4(6):e5774.doi:10.1371/journal.pone.0005774]

6. DPM-S2 [CN# 124030]: Wild Relative

A genotype selected from botanical seeds of *Solanum bulbocastanum* accession PI 545751 obtained from the USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal). It carries the S2 self-incompatibility allele. [Sources: E. Lafleur 2009 (Thesis-U Montreal); J. Soulard 2014 (Thesis-U Montreal); Liu B et al (2009). PLoSONE 4(6):e5774.doi:10.1371/journal.pone.0005774]

7. DPM-S3 [CN# 124031]: Wild Relative

A genotype selected from botanical seeds of *Solanum commersonii* accession PI 472837 obtained from USDA Potato Genebank in Sturgeon Bay, Wisconsin. Plant tissue culture was transferred to the CPGR by Dr. D.P. Matton (IRBV, Université de Montreal). It carries the S3 self-incompatibility allele [Sources: E. Lafleur 2009 (Thesis-U Montreal); J. Soulard 2014 (Thesis-U Montreal); Liu B et al (2009). PLoSONE 4(6):e5774.doi:10.1371/journal.pone.0005774]

8. Abeille [CN# 124032]: Modern Cultivar

Abeille was selected from a cross between 'Saginaw Gold' x 'TATA 9192-15' and released by Le Centre de Recherche Les Buissons, in Pointe-aux-Outardes, Quebec. Tubers are round with flaky yellow skin and yellow flesh. Eyes are shallow, evenly distributed and moderately numerous with slightly prominent eyebrows. It is a high yielding variety, with a long dormancy period (i.e. 9 months) and is moderately resistant to hollow heart, brown heart, and vascular net necrosis. It has a high dry matter content, low after boiling sloughing, and is a tasty variety excellent for boiling and baking. [Source: cultivar description: Abeille - Canadian Food Inspection Agency (canada.ca)]

9. Altitude [CN# 124033]: Modern Cultivar

Altitude was selected from the cross 'LP8314' x 'LP84133' and released by Le Centre de Recherche Les Buissons, Pointe-aux-Outardes, Quebec. Tubers have an attractive appearance described as large, round to oblong with flaky white skin and white flesh. Shallow eyes are numerous, and evenly distributed with slightly prominent eyebrows. It is a high yielding variety with early tuber set and is moderately resistant to common scab and shows good resistance to hollow heart and net necrosis. It is very resistant to brown centre with some sensibility to the herbicide metribuzin. Altitude has a long dormancy period with medium specific gravity and is excellent after a few months in storage. It is very good for French fries and boiling [Source: cultivar description: Altitude - Canadian Food Inspection Agency (canada.ca)]

10. Aquilon [CN# 124034]: Modern Cultivar

Aquilon was selected from the cross 'Hudson' x 'Campbell-13' and released by Le Centre de Recherche Les Buissons, Pointe-aux-Outardes, Quebec. Tubers are oval with white smooth skin and white flesh. Eyes are medium shallow and predominantly apical with slightly prominent eyebrows. It is a high yielding variety with high tuber set, very high specific gravity and is excellent in washing quality, boiling and chipping (until the end of April). Aquilon is very resistant to drought, has a tendency to crack if harvested before maturity and has a medium dormancy period. This variety is resistant to golden nematode (*Globodera*

rostochiensis Ro1), and to common scab. [Source: cultivar description: Aquilon - Canadian Food Inspection Agency (canada.ca)]

11. Brise du Nord [CN# 124035]: Modern Cultivar

Brise du Nord was selected from the cross 'Trent' x 'Chieftain' and released by Le Centre de Recherche Les Buissons, Pointe-aux-Outardes, Quebec. Tubers are round to oval with smooth red skin and white flesh. Eyes are shallow to moderately shallow, well distributed with very slightly prominent eyebrows. It is a high yielding variety with large tubers of attractive appearance, medium dry matter content, medium dormancy period, and moderate resistance to Verticillium wilt. Brise du Nord is very good for boiling. [Source: cultivar description : Brise du Nord - Canadian Food Inspection Agency (canada.ca)]

12. Fjord [CN# 124036]: Modern Cultivar

Fjord was selected from the cross 'TAB8188-04' x 'A7961-1' and released by Le Centre de Recherches Les Buissons, Pointe-aux-Outardes, Quebec. Tubers are oblong with flaky brown skin and white flesh. There are a moderate number of eyes, predominantly apical, set moderately deep with slightly prominent eyebrows. Fjord is a high yielding variety with a short dormancy period and medium to high specific gravity that is good for boiling, baking and for French fries. Fjord has excellent washing quality and is moderately resistant to common scab. [Source: cultivar description: Fjord - Canadian Food Inspection Agency (canada.ca)

13. F02041 [CN# 124037]: Germplasm

Developed by AAFC (AC Blue Pride x Redsen). Niche chip - purple star in flesh. Midseason, purple skinned chip selection with a starburst flesh pigmentation pattern, moderate chip processing quality and potential for niche markets.

14. F08086 [CN# 124038]: Germplasm

Developed by AAFC (Barbara x Monalisa). Fresh Market. Long-oblong selection with yellow skin splashed with pink, yellow flesh, very good boil and bake scores, extreme resistance to PVY and resistance to wart.

3. Evaluations

Eleven accessions including diploid mutant lines were grown in a field evaluation trial at the Fredericton Research and Development Centre. Two replications of fifteen hills were planted on May 30, 2023 and harvested on September 29, 2023. The accessions included in the trial were LRC4373-5B, Ozette-Hebda, EMS5_040_2014_925, PR10-65-5LB, Black Bull, Clone #12-7, Icelandic Red, EMS2_006_2014_100, CTL5_12_2014_589, LRC373-5, and EMS2-114-2014-150. The field evaluation plots are useful for morphological and agronomic evaluations, specific gravity measurements and photographing phenotypic characteristics.

In addition to the evaluation trial, 19 accessions were grown for demonstration in a single replication of ten hills at the Fredericton Research and Development Centre. The accessions grown were Banana, Beauty of Hebron, Candy Cane, Christmas Island Rose, Congo, Crotte d'Ours, Elmer's Blue, Exploits, F87084, Haida, Keswick, Lenape, Lumpers, Makah/Ozette, Marc Warshaw's Quebec, Shepody, Yukon Gold, USDA 41956 and USDA X96-56.

4. Management

We are working on updating passport data and other information in the new Canadian GRIN-Global-CA database which can be accessed from the PGRC website.

Disease testing of accessions includes: i) regulatory testing by a CFIA-accredited lab and ii) in-house testing.

i) Regulatory disease testing was completed in November through a service contract by Agricultural Certification Services located in Fredericton, NB. All new accessions are tested before introduction into the genebank collection. Existing *in vitro* accessions are re-tested on a ten year rotational cycle. This year, 25 clones were grown in the greenhouse from tissue culture to produce mini-tubers and tested for PVA, PVM, PLRV, PotLV, PVS, PVX, PVY, PSTVd and soil-borne bacterial ring rot (BRR). All clones tested negative for associated diseases. Mini-tubers will be distributed to genebank users in the spring of 2024 according to their availability.

ii) All *in vitro* clones in our collections were tested in-house for bacterial and fungal contamination using Potato Dextrose Broth and Richardson's Solution. All clones in the gene bank tested negative for bacterial and fungal contaminants.

Safety Backup: A total of 976 micro-tubers were harvested from 193 of the genebank accessions with additional harvests in progress. On an annual basis, a portion of the micro-tubers are sent to Agriculture and Agri-Food Canada Plant Gene Resources of Canada (PGRC), located in Saskatoon, SK as duplicate safety backups for the conservation of the diverse accessions held on-site at the Fredericton Potato Research and Development Centre. Regular monitoring and data is collected from micro-tubers stored in Fredericton and Saskatoon.

5. Distribution

Accessions within the Canadian Potato Genetic 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.

In 2023, 21 individual requests were filled with a total of 1160 units distributed (Table 1) from 115 unique accessions (Table 3). Half of the requests were for evaluations purposes but requests for the purposes of research were also common. Machado Farm Isla (CN# 124023) was the most requested accession in 2023, which may be due in part to it being a new addition to the collection in 2022. Other popular accessions this year were Eramosa (CN# 105469) and Jemseg (CN# 105483).

Potato clones were shipped across Canada as well as internationally to the United States and Germany (Table 2). Total number of clone units and unique accessions shipped has been steadily increasing year-after-year since the beginning of the COVID-19 pandemic in North America in 2020 (Table 3).

REPOSITORY ITEMS OF INTEREST

Communication

In addition to the requests for clones, many inquiries are made for information about the genebank. This includes requests for clone descriptions and pedigrees, techniques for handling *in vitro* material, and interest in collaborative projects.

The annual Canadian Potato Gene Resources newsletter has a distribution list of approximately 400 recipients.
The current newsletter and several back issues may be accessed electronically through the Government of Canada Publications website.

Table 1
Distribution of Clones by Purpose in 2023

Purpose of Request	Number of Requests	Number of Units	Clonal Types		
			In vitro plantlets	Field Tubers	Mini-Tubers
Evaluation	10	189	14	130	45
Research	6	705	57	489	159
Conservation	3	205	185	15	5
Education / Demonstration	2	61	4	42	15
Total	**21**	**1160**	**260**	**676**	**224**

Table 2
Requests by Destination in 2023

Destination	Number of Requests
Atlantic Region	9
Central Canada	7
Prairie Provinces	1
West Coast	2
International	2
Total	**21**

Table 3
Five-Year Compilation of Clone Distribution Data from 2019 to 2023

Year	Purpose of Request				Units Distributed			Unique Accessions Requested
	Research/ Evaluation	Education	Conservation	Total	Tubers	*In vitro* plantlets	Total	
2019	19	3	0	22	244	234	478	125
2020	3	0	0	3	0	43	43	20
2021	21	1	0	22	176	276	452	21
2022	11	1	0	12	465	59	524	54
2023	16	2	3	21	900	260	1160	115
Total	70	7	3	80	1785	872	2657	-

Meetings and Miscellaneous Information

For the second year, Dr. Benoit Bizimungu (CPGR curator) and Sylvia Steeves (technician) virtually attended the Plant Germplasm Operations Committee (PGOC) Meeting and Curator Workshop organized by the United States Department of Agriculture (USDA) from June 12-13, 2023.

During October and November of 2023, Dr. Benoit Bizimungu and Stephanie Browne (technician) along with genebank curators and colleagues from the Canadian Clonal Genebank in Harrow, ON and Plant Gene Resources Canada in Saskatoon, SK received a series of webinar training sessions in the Germplasm Resource Information Network (GRIN-Global) database hosted by Marty Reisinger (USDA). GRIN-Global is an information management tool designed to store and manage plant genebank data from across the globe.

Donor Agreement

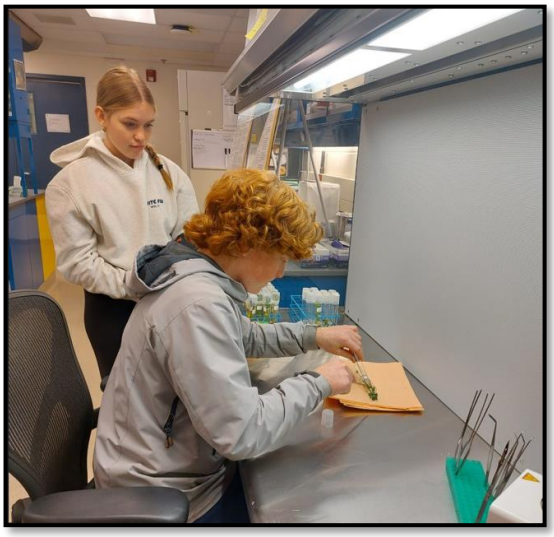
Donors wishing to provide plant material to Agriculture and Agri-Food Canada (AAFC) for the purpose of research, conservation and distribution by Plant Gene Resources of Canada must complete a donor agreement form. Decisions on accepting material into the Canadian Potato Gene Resources collection are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

Visitors

May 11, 2023 – The “I am a Public Servant” event saw a Senior Management Team visiting the Fredericton Research Centre take a tour of the facility that included the Potato Genetic Resources Genebank.

STB-Coastal Region Director General Benoit Girard (front) and colleagues are welcomed into the lab by Research Scientist and Genebank Curator, Dr. Benoit Bizimungu (not pictured) showcasing some of the tubers, micro-tubers and tissue culture that make up the genebank collection. Erica Fava (back), Josée Owens (not pictured) and David DeKoeyer (not pictured) provided a further tour of the FRDC.

November 1, 2023 – Take Your Kids to Work Day saw several high school students tour the Fredericton Research Development Centre learning about what it is that their parents and other FRDC staff do for work.



High School Student, Caleb, performs a tissue culture cutting of a plantlet from the genebank repository under the watchful eye of fellow student, Avayah.

November 10, 2023 – Natural Resources Canada's Chief Scientist, Dr. Rajana Sharma, drops in for a visit to tour the Potato Genetic Resources Genebank and to talk about the future of cryogenic storage.

Dr. Rajana Sharma (left) observes a collection of in-vitro plantlets from the potato genebank repository presented by Research Scientist and Genebank Curator, Dr. Benoit Bizimungu (right).

December 13, 2023 – AAFC Director General Shawn Audette also stopped by for a tour of the facility.

Dr. Benoit Bizimungu (right) showcases the diversity of potato tubers that grow from the tissue cultures that make up the genebank collection. Shawn Audette (left) inquires about the origins of some of these unique traits.

December 15, 2023 – Students from Stanley High School's Agriculture 110 course learn about career opportunities within the agricultural sector of New Brunswick by visiting Agriculture and Agri-Food Scientists working at the Fredericton Research Development Centre.

Two teams of students compete in a tuber-matching game where they put to good use the knowledge they gained about how potato clones acquire their names. The winning team made the most correct matches between clone names and their corresponding potato.

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 a 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 Canadian National Genebank Information System (GRIN-Global-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 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 Portable Document Format (PDF), please send your e-mail address to Stephanie.browne@agr.gc.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 to us!

Curator's Note

I am pleased to announce and welcome Stephanie Browne at the Canadian Potato Gene Resources (CPGR) as the acting Potato Gene Resource Technician, in replacement of Sylvia Steeves who is currently on leave. Stephanie has a molecular biology background but was teaching for about 7 years before returning to science and eventually joining the Fredericton Research and Development Centre. She is excited to be part of the gene bank team and will be your contact for potato germplasm requests and distribution.

On a different note, I am also pleased to let potato genebank users know that USDA 41956 (CN# 105540) accession is now available for distribution as tissue culture. The clone has been maintained as field tubers at the Benton Ridge Breeding Substation for many years and was successfully introduced *in vitro*.

Research, Development and Technology transfer activities at the CPGR during the year 2023 centered on continued maintenance, distribution, and characterization of germplasm, with some new targeted acquisitions. An important highlight for the CPGR in 2023 was the introduction of a haploid inducer PL-4 line for use in the conversion of tetraploid germplasms into dihaploids for diploid breeding. We also added several wild potato relative genotypes currently used in various genome sequencing and evaluation initiatives.

Finally, I would like to invite our readers to send us research news or updates for publication in our newsletter to share with the gene bank community. I look forward to your continued support and collaboration to advance genetic resources conservation and utilization.

TO RECEIVE THE NEWSLETTER, PLEASE CONTACT:

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