INTERVIEW

John Bamberg, U.S. Potato Genebank

By Joe Kertzman, managing editor, *Badger Common'Tater*

NAME: John Bamberg

TITLE: Project leader, U.S. Potato Genebank (USPG)

COMPANY: USDA / Agricultural Research Service

LOCATION: Sturgeon Bay, WI

HOMETOWN: Rural Freeport, IL

YEARS IN PRESENT POSITION: 29

PREVIOUS EMPLOYMENT: Assistant to project leader

SCHOOLING: Plant Breeding and Plant Genetics, UW-Madison

ACTIVITIES/ORGANIZATIONS: Potato Association of America

AWARDS/HONORS: Professor, Horticulture Dept., UW-Madison

FAMILY: Wife, Ingrid, and children, Marie, Ben, Paul and Joe

HOBBIES: Bicycling, gardening

There is only one facility designated to support the germplasm needs of the U.S. potato industry, and it is in Sturgeon Bay, Wisconsin.

The U.S. Potato Genebank (USPG) coordinates all aspects of importation, classification, preservation, multiplication, documentation and distribution of germplasm. It is the most comprehensive and active collection in the world.

Often cited as a top vegetable and one of the three most important food crops, the potato nevertheless remains susceptible to pests, diseases, environmental stresses and quality problems.

Fortunately, there is a great wealth of wild and cultivated potato varieties with genes that mitigate the problems, and they are relatively easy to hybridize.

To efficiently keep that diversity in genebanks, researchers need to understand the diversity in the wild.

In 2016, the genebank staff of the Peninsular Agricultural Research Station (PARS) in Sturgeon Bay, Wisconsin completed 25 years of expeditions in the southwest United States, mapping and prioritizing hundreds of collection locations for their diversity, and conducting numerous DNA marker studies on the factors that predict patterns of diversity.

EXOTIC GERMPLASM

Potato cultivars have more exotic germplasm in their pedigrees than any other major crop. Of the last eight cultivar releases from the Wisconsin breeding program, six have parents of at least one wild species from the PARS genebank, the only site in the country from which breeders can obtain these resources.

Also in 2016, Simplot got clearance for its second generation of Innate potatoes with reduced bruising, reduced asparagine, resistance to late blight and enhanced cold storage capability. These advances promise huge savings in increase processed quality, reduced pesticide use and reduced acrylamide.

Above: John Bamberg, project leader of the U.S. Potato Genebank, says his job involves helping breeders move genes for tuber quality, and pest, disease and environmental stress resistance from the little inedible wild species tubers (in his left hand) to productive new varieties (in his right hand).

This technology developed by Simplot scientists was made possible by adapting genes from wild and cultivated potatoes from the PARS potato genebank.

The USPG is a cooperative effort between the USDA Agricultural Research Service (ARS) and all 50 SAES (State Agricultural Research Stations), with special support from the University of Wisconsin.

John Bamberg has been the project leader for nearly 30 years. With a Ph.D. from the University of Wisconsin-Madison in Plant Breeding and Plant Genetics, he is the Editor in Chief of the *American Journal of Potato Research* and serves as chairman of the Potato Crop Germplasm Committee.

Why do we need a genebank, and how has the USPG contributed to potato progress over the years? The current breeding pool is strong, but there are lots of ways we could benefit from "new blood." Imagine the delays, inefficiency and duplicated effort there would be if there was no genebank and every scientist in the United States who wanted to pursue new genetics in exotic potato relatives had to start from scratch.

How would he get taxonomic information on species boundaries and relatedness to cultivars? If, having gotten this information, and he settled on a species to study, could he organize an expedition to Latin America to collect samples for himself?

Then, too, potato is a "prohibited" quarantined plant, which means it is illegal to import except by special APHIS (Animal and Plant Health Inspection Service) permit. He would have to determine how to efficiently preserve, grow and crossbreed the species, all while keeping it disease free.

The potato crop depends on a lot of different inputs, but these are often available from several brands and vendors. In contrast, for unique genetic tools outside of the current breeding pool, U.S. breeders have only *one* practical source—our own Wisconsin genebank.

Above: Potatoes are planted in a U.S. Potato Genebank (USPG) greenhouse to multiply the seed lots. Tina Wagner is shown hand pollinating for "seed increase."

How many potato species does the genebank have? USPG has about 5,000 populations of approximately 100 potato species. Almost all are *not* cultivated—they were collected from plants growing wild somewhere in Latin America.

Although wild, many of these species can be incorporated into the crop with fairly simple techniques. For several reasons, it is more efficient to keep these stocks as seed populations, which involves hand pollination of thousands of plants each year in the greenhouse.

Of course, cultivated potato is a clonal crop, so USPG also has a collection of about 1,000 cultivars

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from around the world, plus breeding and genetic stocks.

These are kept and distributed in sterile test tube culture. All these stocks are subject to a rigorous virus testing program, have extensive associated information in an online database, and can be ordered free of charge.

How is it possible to genetically improve the potato? What do you look for and what does your research entail? USPG supports advances in potato genetics and breeding by providing raw materials. Our main responsibility is to acquire, classify, preserve and distribute the germplasm.

But to get maximum impact from that service, we also need to do research and development.

How and where is the most genetic diversity to be had, and how do we avoid losing it once we get it into the genebank? We are answering such questions with DNA markers.

We also study how to keep improving our techniques for producing plenty of seeds and storing them in a way that maintains high viability and avoids contamination with viruses.

The germplasm is not much good if genebank staff doesn't also discover and provide information on how to grow and crossbreed with it. The staff must keep accurate, detailed and organized records on everything known about the history and qualities of the stock.

The genebank collection is just a sample of what is in the wild. We need to know if it is a good one. So for the past 25 years, we have collected and studied the two potato species native to the southwest United States as models.

We screen for new traits. We want to dabble in research in as many uses of germplasm as possible, so we will have a bit of experience from which to help customers from all disciplines.

Above: Two acres of potato seedlings were transplanted at the Hancock Agricultural Research Station, involving many USPG research projects.

Since it is not practical to attempt to research all traits wholly in-house, we do joint research projects with many different specialists across the country and world, including pathologists, physiologists, breeders, entomologists and food scientists.

While we don't usually interact directly with growers or processors, we are keen to keep abreast of their needs. Finally, USPG germplasm ultimately originated in Latin America, so we are engaged in close collaboration with our counterparts there, particularly in Peru.

I understand the U.S. Potato Genebank (USPG) is a cooperative effort between the USDA Agricultural Research Service (ARS) and all 50 SAES (State Agricultural Research Stations), with special support of the University of Wisconsin. What is the role of the USPG in Wisconsin? The USPG was started in the state because the University of Wisconsin has long been a powerhouse of research on potato germplasm.

Stan Peloquin used our stocks to discover how to bring exotics and cultivated forms to the same level for breeding. He figured out how to manipulate crossing, directly resulting in the Yukon Gold potato variety.

Others contributed pioneering techniques to overcome crossing barriers, like Bob Hanneman's discovery of inbreeding and genetic cross-ability factors, and John Helgeson's somatic fusions.

Jiming Jiang and John Helgeson isolated a key gene that provides durable resistance to late blight from a wild species that had been collected in Mexico and preserved and studied

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in the genebank long before its potential was recognized.

Jiang is also studying chromosomal and genome evolution between potato and various wild species.

Jiwan Palta used genebank stocks to study and improve tuber calcium to combat tuber defects, and similarly advanced frost hardiness with USPG exotic species.

Dave Spooner extensively collected in Latin America, and organized all of our species into logical groups, and Shelley Jansky, Dennis Halterman and Paul Bethke continue to build on Wisconsin know-how by releasing breeding stocks that put valuable traits like resistance to verticillium, early blight, late blight and scab from USPG germplasm into cultivated background.

It would likely take several issues of the *Badger Common'Tater* to cite all the Wisconsin researchers who have helped collect, study and deploy USPG germplasm, not to mention the many professionals who have been trained at the University of Wisconsin and are now using USPG germplasm for potato improvement in many other states and countries around the world.

What has the practical impact of the USPG been? The USPG is not just a potato museum or a place to get weird potatoes for theoretical research projects. At least 70 percent of named U.S. cultivars have our exotic germplasm in their pedigrees.

In Wisconsin, of the past eight cultivar releases from the breeding

Left: Big tuber mutants of the wild diploid Mexican species *Solanum cardiophyllum* are shown next to typical little wild tubers.

Right: Alfonso del Rio collects wild potatoes in the Pinaleno Mountains of southeastern Arizona.

program, six have USPG wild species germplasm as parents.

We now distribute about 10,000 samples each year, an increase of more than 25 percent over the previous five-year project term. Who is consistently our biggest customer? Our own Wisconsin scientists.

Why is gene diversity so incredibly important? The sports model illustrates why genetic diversity kept in a genebank is important. In sports, you often depend on just a few highly specialized elite players to win the game. It's the same with the cultivars in commercial potato production.

But in sports as in a potato crop, you are smart to hedge by having backups ready to take the field quickly if the stars are injured or demands of the game change.

Similarly, genebanks keep genetic alternatives "on the bench," and study and groom them so they are fit to be quickly deployed when needed.

Having and studying genetic diversity also expands our horizons. Nobody recognized the potential of a backward high jump until Dick Fosbury demonstrated his "flop." Similarly, until such things were noticed and studied in diverse germplasm from the genebank, nobody expected some potatoes could be chilled and not make black chips, or that they could be exposed to light and not get green, sprout after 16 years of storage, or survive being frozen. All these traits have practical application.

We need multiple genetic options to address known problems from multiple angles. But we also need general diversity to increase the odds that we will have solutions to unpredictable new problems.

Genetics from USPG can touch just about every aspect of how the crop can be more efficient and profitable—more disease, pest and stress resistant.

This allows growers to make better use of water and fertilizer for improved processing quality. They can identify better nutrients to impress the consumer and generate more demand.

And genebank stocks can be useful even before they become parents of new cultivars. Consider a trait like tuber calcium, where some species have six times as much as cultivars. Such extreme stocks make great tools for studying the physiological and genetic basis of a trait.

I believe the Peninsular Ag Research Station (PARS) is the state farm where you do your research, is that correct? Where is it located, and what research and development is specifically done at PARS? In the late 1940's, PARS, a 120-acre fruit research farm owned by UW-CALS (College of Agricultural and Life Sciences), was selected as the host site for USPG.

This site near Sturgeon Bay was expected to be relatively cool in summer, thus allowing better

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Top: A primitive potato species is cultivated in Peru. USPG germplasm ultimately originated in Latin America, so the staff of the genebank is in close collaboration with their counterparts there, particularly in Peru.

Bottom: A close-up view shows germination testing in a USPG greenhouse.

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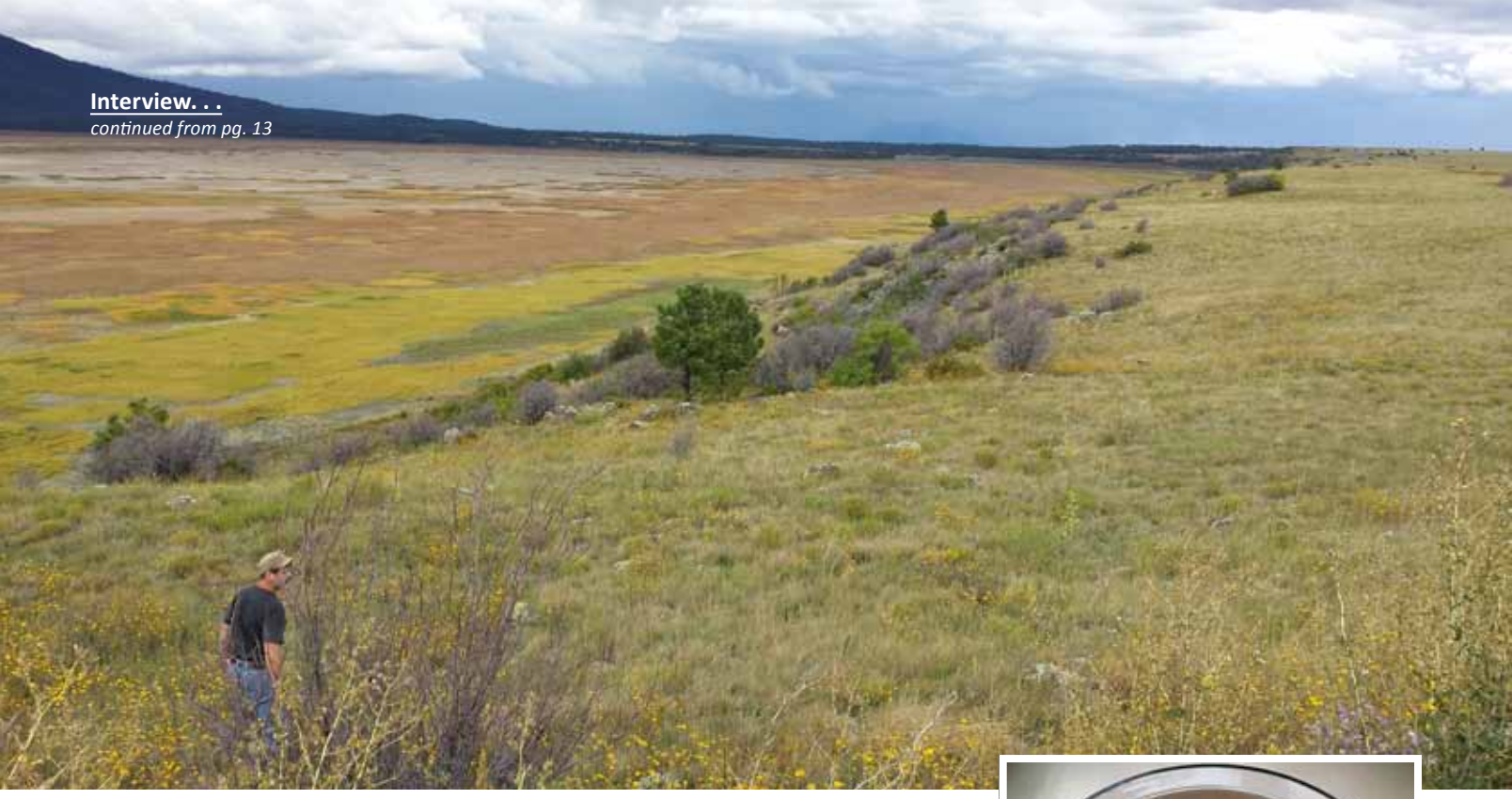


botanical seed production (the form of preservation for 90 percent of the collection). It was thought to be less prone to virus spread.

Finally, it is isolated from the state's production region (Central Sands), and research (Madison and Hancock) and breeding (Rhinelander) sites, so there would be a buffer just in case some pest or disease was accidentally imported with foreign germplasm.

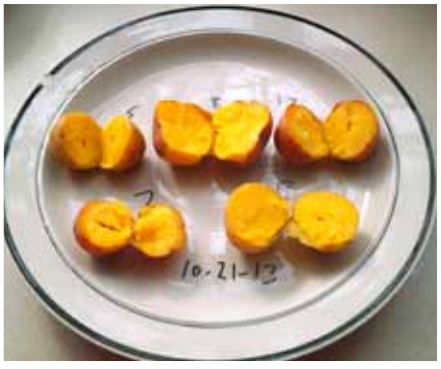
It would be interesting to calculate, on a per-acre and per-budget dollar basis, the impact of PARS over the past 70 years just resulting from its serving as a host site for USPG. PARS has been the source of materials for potato improvement that were not available from anywhere else in the nation.

PARS supplied the raw material that made it possible for USPG staff, associates in Madison and other scientists across the country and around the world to generate a lot of potato progress, many hundreds of useful research studies published, graduate students trained and new cultivars bred.

Potato researchers, breeders and germplasm specialists around the world recognize the name of the small Wisconsin town of Sturgeon Bay only because PARS has provided a long-term home base for the world's premier source of potato germplasm, technology and information.

Imagine how much better you can navigate after the first detailed map of some place is available. We now have such a map for potato. And where did the specialized stock that allowed the potato genome to be sequenced originate? It was right here at PARS.

Leadership of five national and international programs is based at PARS—the two national genebank partners, which are USDA/ARS and the multi-state cooperative project NRSP-6, the federal crop advisory committee (CGC) for potato and the world's premier potato research journal, *American Journal of Potato Research* published by the Potato Association of America. PARS genebank staff also instigated the international Association of Potato Intergenebank Collaborators with USPG staff serving as U.S. representatives.



Top: This issue's interviewee, John Bamberg, project leader of the USPG, collects wild potato samples at Mormon Lake (northern Arizona) in 2015.

Right: A Criolla (egg yolk) specialty type potato is type selected for eating quality.

Are there always genetic answers to problems like potato bruising or tuber defects, hollow heart, diseases, pests and acrylamide?

We realize that fighting diseases, pests and stress-related problems like bruising, sugar end and hollow heart also depends on non-genetic innovation.

Improvements in IPM (Integrated Pest Management), chemicals, water and fertilizer management, machinery, seed certification, etc., are also needed. But we want to find out how germplasm options can best

interact with and maximize such non-genetic advances.

How are the U.S. Potato Genebank and PARS funded? USPG is mostly supported by federal revenue. About 80 percent of that is provided directly by USDA/ARS, and about 20 percent comes through the aforementioned national multi-state cooperative project, NRSP-6, originally famous as IR-1.

USPG staff members are disciplined enough to have the mindset of the genebank being like a big business that is being pressed by a tough competitor.

We aim to provide the maximum service we can, always finding a way to say "yes" and go the extra mile for the customer, operating as frugally and efficiently as we can, and rejecting the idea of charging the taxpayer again for germplasm services he or she has already paid for.

We welcome *Badger Common'Tater* readers to visit us in Sturgeon Bay and learn what we're all about.

Are you addressing late blight and other fungal, bacterial and viral diseases? When new problems arise, we prepare specialized samples and hybrids for testing with cooperators. For the late blight crisis in the early 1990's, we sponsored testing in multiple U.S. states, Mexico, Canada, and Russia—finding new sources of resistance in the species *microdontum* and *okadae*.

For Zebra Chip, we helped screening efforts in Washington State and Texas that identified the species *verrucosum* as particularly psyllid resistant. We are currently coordinating a project to screen germplasm for resistance to *Dickeya* and welcome advice from *Badger Common'Tater* readers.

What does the future hold for growing and crossing potato stocks, and what do you hope for the USPG in the future? Genetic information and manipulation is rapidly advancing, and we are looking forward to how that will help us improve genebank technology and service. Of course, as researchers and breeders get these better tools, demand for USPG raw materials will also increase, so we need to be ready.

Some business coaches say that if you keep doing something the same way for long enough, it will eventually be wrong. So how can we innovate?

We are looking into how germplasm could improve the feasibility of specialty cultivars, and even potato alternatives to grain in noodles, bread, beer and sweetened breakfast foods. Farming for potato protein extract already has commercial application.

Above: As part of its diversity initiative, the staff members of the USPG discovered a floral mutant, *Coronita*, with multiple pistils but no anthers.

As the most consumed vegetable, potato is already familiar, popular, and affordable, giving it tremendous potential to expand if we can provide consumers with new selling points of improved taste, convenience and quality.

It is intriguing to think about how USPG germplasm could be deployed to expand potato into such alternate outlets, increasing the demand, profitability and positive nutritional impact of potato on society. BC'T