US Potato Genebank—service and research for potato genetic improvement

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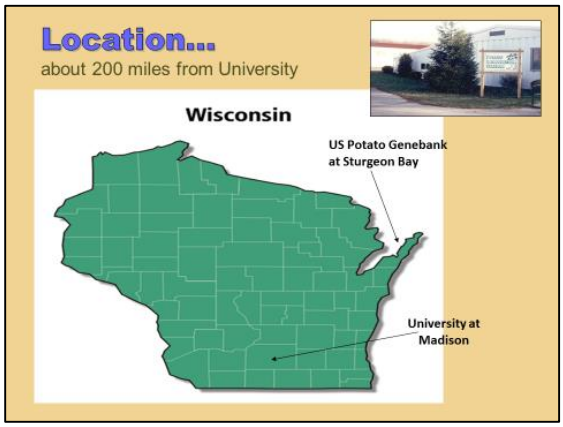
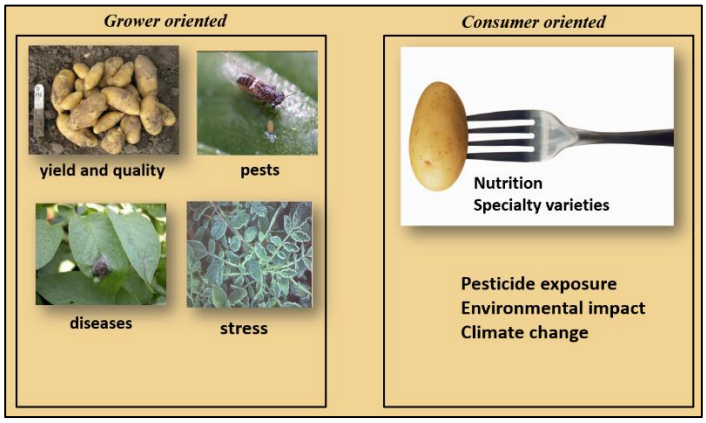


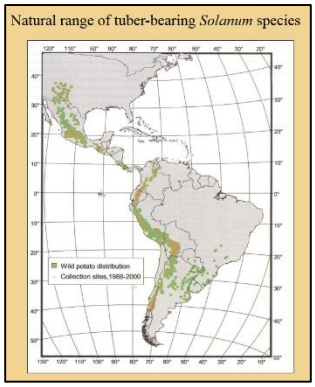
The US Potato Genebank (USPG) is the federal working collection for potato germplasm, located at Sturgeon Bay, Wisconsin. It is part of the National Plant Germplasm System, managed by USDA-Agricultural Research Service in partnership with the state agricultural university system. The administrative home for both USDA and state staff is at the UW campus at Madison.

Several other US national genebanks maintain multiple crops, but USPG is responsible just for the "Irish" or "white" potato and its wild relatives. Botanically, this is defined as the tuber-bearing species of the genus *Solanum*. A single genebank devoted to potato is warranted considering the stature of potato as the world's most popular and productive vegetable. There is tremendous potential in deploying genetic resources to improve a crop that already has so much economic and nutritional impact. USPG is also particularly needed because the potato crop has many challenges for both producer and consumer-- like biotic and abiotic stress, a need for enhanced nutritional and other quality traits, and reduced pesticide exposure and environmental impact.



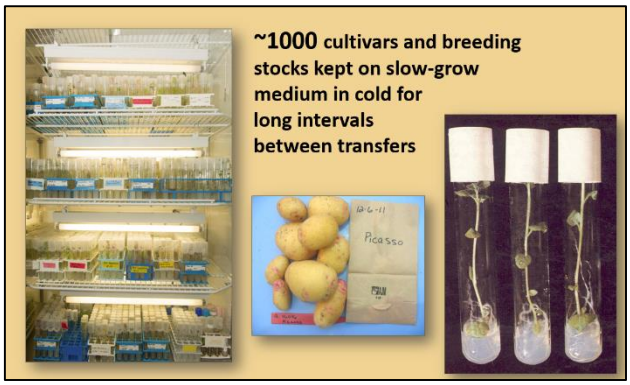
The ancient approach to germplasm preservation was to keep all the available genetic diversity growing in the field every season. Then, when an unusual challenge from weather or pests happened, at least some plants would be fit enough to produce a crop. But with modern agriculture, only a few select individual varieties are grown—those fine-tuned to an optimum environment, with the goal of maximizing production and efficiency. Obviously, this situation created the need to keep the genetic resources that were no longer in the field someplace else where they could be readily deployed when the needs of the crop changed. The analogy to a toolbox is an apt one. To maximize the chance of being able to fix any problem that might come up, we need more than just the tool being used at the moment. We need the maximum diversity of tools kept in backup. We also need to keep those tools in good working condition, well organized, and know how to

use them. In the germplasm sense, this means the genebank needs to seek and preserve the maximum potato genetic diversity, preserve it free of systemic disease (e.g., viruses), organize it into species and subspecies groups, evaluate and characterize it for useful traits, determine techniques for bringing exotics into the breeding stream, and keep all this material and information readily available to germplasm users. Thus, USPG aims to provide a toolbox of genes for known, and yet-unknown challenges in the form of disease-free, viable stocks with accurate documentation. USPG provides this germplasm to any requester in the USA or abroad, free of charge. We also conduct research to find ways to maximize the usefulness of the germplasm to the industry.



Potato is native to the Americas, and current taxonomy recognizes about 100 wild species and one major cultivated species (Spooner et al. 2014).

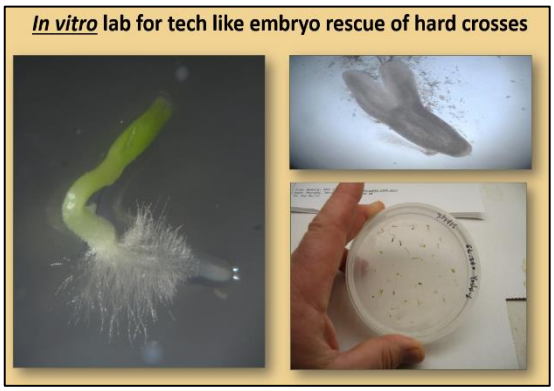
Potato has two modes of reproduction which dictate the technical methods of preservation and distribution used at USPG. The potato crop consists of tubers-- a vegetative organ. Since all commercial potatoes are genetically heterozygous, maintaining the exact individual cultivar requires clonal reproduction. Repeated tuber grow-outs could be done, but that would make it very hard to ensure that the stocks were free of diseases. Therefore, USPG keeps and distributes all of its ~1000 clonal stocks in sterile tissue culture. The normal distribution sample from the genebank is 2-3 test tubes of each cultivar (to ensure that at least one plantlet is established).



The other method of reproduction is sexual-- pollinating flowers to produce berries and botanical seeds. This has great advantages, since potato seeds, properly dried and kept in a regular freezer will usually maintain high germination for several decades. Potato seeds also have the advantages of being relatively imperishable, small and light for shipping. The 5,000 samples kept in the form of seed populations (mostly the wild species) need to be regenerated when inventory and germination decline. This is done by planting and hand-intermating seedling plants in the greenhouse. The usual distribution sample is 50 seeds (which typically

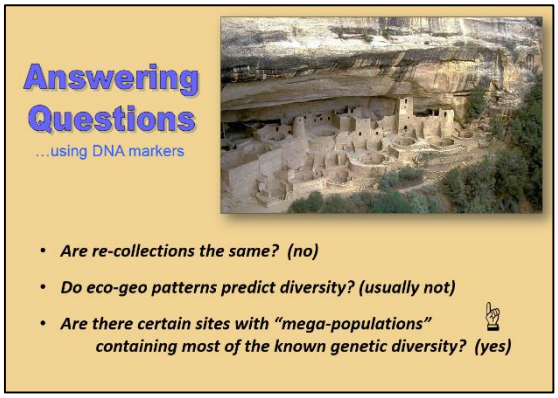
have >75% germination). In contrast to tissue culture clones, a packet of most species' seeds received from USPG will be like a family-- a mix of somewhat variable siblings.

Another mission of USPG is to do research to keep the tools in our genetic toolbox "in good condition" and find out "how to use them"—both for the benefit of the genebank staff and germplasm recipients. For example, USPG staff use DNA markers to identify the populations within species that are most rich in genetic diversity. So, if a certain species has 100 populations in the genebank,

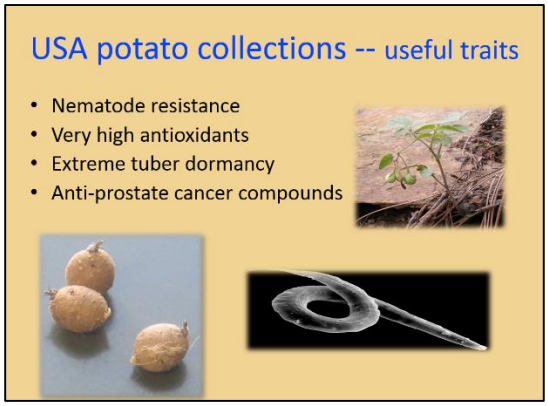


and 25 of those are found to capture most of the total genetic diversity, we have identified an enriched set for more efficient research and breeding (Bamberg & del Rio 2014). To improve genebank service, staff are also engaged in research to maximize germplasm-handling techniques. This can include methods to maximize seed longevity and germination, ways to obtain hybrids between exotics and cultivated forms (e.g., embryo rescue), and a variety of other germplasm-handling techniques (Bamberg et al. 2009).

All these previous considerations of genetic diversity have been confined to what is already in the genebank. But what of the status of diversity still in the wild, the benefit of adding it to the genebank, and the best way to collect it? To address these questions, genebank staff have been actively studying and collecting the two wild potato species native to the USA for over 20 years. This work has answered questions about the status and dynamics of germplasm in the wild using DNA markers (Bamberg & del Rio 2011).

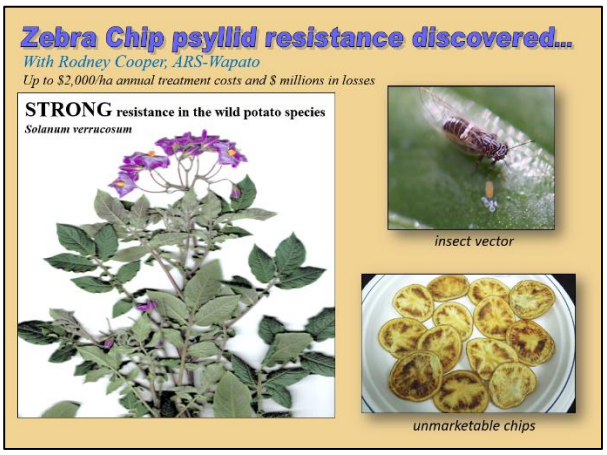


Collecting activity using southwest USA species as models has also resulted in the acquisition and evaluation of new germplasm with useful traits, like nematode resistance (Brown et al. 2004), very high antioxidants (Nzaramba et al. 2007), extreme tuber dormancy (Bamberg 2010), and anti-prostate-cancer compounds (Nzaramba et al. 2009).



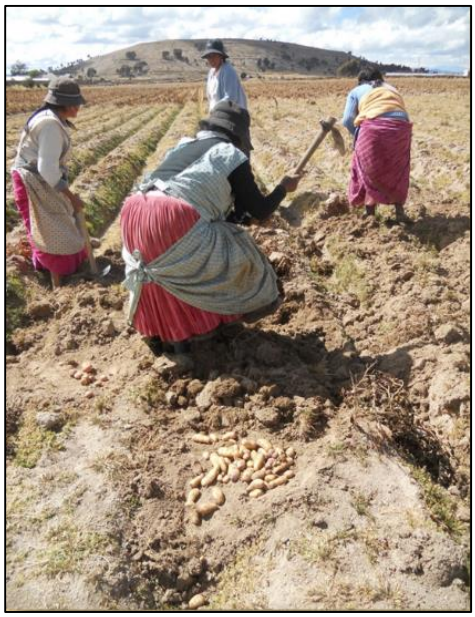
USPG conducts research to evaluate for useful traits in all the species, not just those from the USA. However, since the genebank aims to serve all of the disciplines of potato science (genetics, pathology, entomology, physiology, etc.), it is best for genebank staff to be generalists rather than specialize in any single trait. For this reason, in-house studies tend to

focus on simple traits which do not require investment in special expertise, facilities or equipment. Some examples are floral mutants (Bamberg et al. 2014), tuber pH (Kiszonas & Bamberg 2010), tuber greening (Bamberg et al. 2015), hormone mutants (Bamberg & Miller 2012), and frost hardiness (Bamberg et al. 2005).



Studies on many other traits are conducted in cooperation with experts in various disciplines of potato research and breeding. Examples are high tuber tomatine (Bamberg et al. 2016), antioxidants (Pillai et al. 2013), calcium (Bamberg et al. 1993), folate (Robinson et al. 2015); and Colombia Root Knot nematode and Zebra Chip vector resistance (Cooper & Bamberg 2014).

Most of the germplasm in the USPG was donated from Latin America. So genebank staff are also actively involved in projects to share germplasm benefits with these donor countries. One basic way of accomplishing this is repatriating disease-free, viable propagules free of charge on demand, in effect providing genebank services for the potato scientists and breeders of the donor country. Beyond that, we have been engaged in cooperative projects in Peru (for example) for many years to test and deploy frost and drought tolerant germplasm, novel hybrids and new methods for growing and using the crop.



All these activities of USPG are pursuant to using germplasm to make a future potato crop with higher quality, profit, and nutritional value; lower input needs and lower environmental impact; more resistant to pests and stresses, and more competitive for market share. More details of USPG activities and publications, full contact information, and access to all germplasm data in GRIN (2016), the Germplasm Resources Information Network website is available through the genebank website (http://www.ars-grin.gov/nr6/) or by contacting the author.

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