ANNUAL REPORT
FY 2019

NRSP-6: UNITED STATES POTATO GENEBANK

Acquisition, Classification, Preservation, Evaluation and Distribution of tuber-bearing *Solanum* Species.

COOPERATIVE AGENCIES AND PRINCIPAL LEADERS

State Agricultural Experimental Stations		Representative
Technical Representatives		
Southern Region		C. Yencho
Western Region		D. Holm
North Central Region		D. Douches
Northeastern Region		W. De Jong
Administrative Advisors		
Southern Region		J. Meullenet
Western Region		J. Loper
North Central Region	Lead AA	B. Barker
Northeastern Region		F. Servello

United States Department of Agriculture		
ARS		
Technical Representative	Chair (2020)	R. Novy
National Program Staff		P. Bretting
		J. Munyaneza
Midwest Area		JL. Willett & P. Simon
NIFA		E. Kaleikau & L-S Lin
APHIS		R. French
NRSP-6 Project Leader		J. Bamberg
Agriculture & Agrifood Canada		B. Bizimungu
Industry	Chair (2019)	J. Parsons

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. Acquisitions and associated work

In 2019, we collected 15 germplasm accessions from an expedition to AZ, NM, TX, and CO with the support of USDA Plant Exploration office at Beltsville. We found potatoes in completely new places, notably Chimney Rock National Monument (→). Another special feature of this year's expedition was participation of UT and OH collaborators doing DNA collection for a joint NSF grant relating anthropology and genetic patterns of wild potato populations. Each new accession is online in GRIN, and is linked to a detailed collecting trip log describing its origin.

We also sought and received 18 new clonal breeding stocks and cultivars from various donors. We continued the process of acquiring clones for which PVP has expired. The NRSP-6 web page (http://www.ars-grin.gov/nr6) was updated to include all new stocks and screening information. Clients who have ordered from NRSP-6 within the past four years were contacted three times in 2019, informing them of new stocks of true seed, tubers, *in vitro* plantlets, or other samples. We used email and the website to extend technical instructions of various types.

B. Classification

Dr. Spooner completed work documentation in the herbarium specimens moved to University of Wisconsin. We continued research on crafting core collections within species *fendleri* and *boliviense* and started characterization of species *kurtzianum*.

C. Preservation and Evaluation

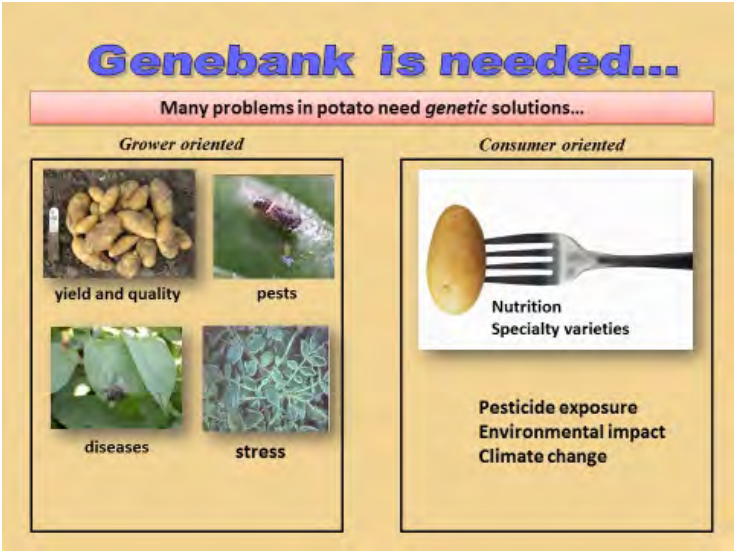
Propagation: In 2019, we hand-pollinated 195 families of 20 plants each in the greenhouse for seed increase (↓) and performed 19,522 *in vitro* transfers to maintain fresh propagules of clonal stocks.

Germplasm health monitoring: We did 889 tests for viruses.

Viability monitoring: We did 1,579 replicated germination tests, 31 ploidy evaluations and 38 tetrazolium seed viability assays. These statistics do not include the hundreds of assays performed researching ways to improve the efficiency of seed germination and ploidy determinations.

Trait evaluation and Technology:

Potato germplasm has a broad spectrum of traits that can benefit both the grower and consumer (→). The genebank's supporting role for research is not just to supply propagules, but to facilitate discovery and characterization of these traits through evaluation and technology development.



Peru connection: In 2019, we continued building evaluation partnerships with many expert cooperators. Particularly notable among these is our cooperation with Peru (↓), deploying novel germplasm in breeding that has now resulted in new registered cultivars.

Nearly two acres of individual field plots, four large screenhouses, ten greenhouse compartments and a tissue culture lab were available at the UW Ag Research Stations at Hancock (→) and Sturgeon Bay, Wisconsin. These were used for seed, tuber and *in vitro* multiplication, and numerous evaluation experiments.

Egg-yolk specialty potatoes: This year's mass selection population had 100% individuals with dark golden flesh. The initiative to produce a selfing line also appears to be succeeding, with some S3 families with uniform golden flesh (→).

Root vigor screening with new "spaghetti" watering system: We started evaluation of the nearly 100 populations of *S. kurtzianum* in the NRSP6 genebank. The new irrigation system allowed characterization of root vigor differences and tolerance to deficient nitrogen and drought (←), as well as tuber yield and size (↓).

Dickeya / Zebra chip psyllid DNA genotyping, metabolites: We built on previous cooperative screening with Cornell and USDA scientists that found extremes of resistance to these important diseases by creating segregating populations that could be used to detect genetic and metabolite markers associated with the traits.

Tuber trait characterization technology: Since the inception of the genebank, we have not had an adequate way to generate tubers for systematic analysis of tuber traits. For this we need optimized conditions to stimulate tuberization, even for species with unusual daylength and temperature requirements. We needed a way to produce replicate batches of tubers over time in exactly the same conditions. We needed the ability to precisely apply test environments like varying fertilizer, water, etc. Finally, we needed to be able to do all this with tight phytosanitary control to minimize the risk of disease spread. This year we received a generous donation of two specialized tuberizing chambers (←). We intend to complete installation and use them for numerous projects that study tuber traits.

Crossing technology: NRSP6 germplasm is already in the pedigrees of many commercial cultivars, but we could expand that benefit of exotic species by making hybridization easier. This year we synthesized and selected a line of *verrucosum* backcrossed into *tuberosum* cytoplasm. Its superior qualities as a bridge species include self incompatibility, very vigorous flowering, buds that do not fall off, and high female fertility. With this unique stock, we were able to make novel interspecific hybrids (→).

Exploring novel approaches to drought tolerance: This year we followed up on a longstanding hunch that mutants deficient in the plant hormone gibberellin might be more drought tolerant. Populations that segregate for these dwarf mutants revealed that mutant seedlings (←) withstand drought stress that kills all of their normal siblings. This could be a useful clue to breeding for drought, especially if the gene confers tolerance in heterozygous form. Water use efficiency will be an increasingly important trait as water availability is expected to become more limited with climate change.

D. Distribution

Distribution of germplasm is at the heart of our service. The volume and types of stocks sent to various consignee categories are summarized in the table below. In 2019, a total of 6659 units of germplasm were sent as 183 domestic orders to requesters in 34 states, and 3383 units of germplasm as 14 foreign orders to 10 other countries. About 1/3 of the domestic orders are for public breeders and geneticists, 1/3 for pathology, physiology, entomology, taxonomy and education, and the remaining 1/3 for private germplasm users. See Impact Statement section for how this germplasm is being put to work.

In 2019, we maintained the popular offering of 100 cultivars as tubers by devising and implementing an iron-clad disease control and quarantine program for their production (full details available at our website).

	Units of Germplasm Sent[1]							
Category	Seed	TU	IV	DNA	Plants	TF	Total	PIs
Domestic	1088	3679	1073	46	754	19	6659	5093
Foreign	3215	0	168	0	0	0	3383	377
Total	4303	3679	1241	46	754	19	10042	5470

[1] Types of stocks sent/(number of seeds, tubers or plantlets per standard shipping unit): Seed = True Seeds/(50), TU = Tuber Clones/(3), IV = *in vitro*/(3), DNA = dried leaf or tuber samples/(1), Plants = Rooted Cuttings/(1), TF = Tuber Family/(1).

E. Outreach

Staff attended local, regional, national and international potato research and breeding professional meetings and gave presentations. Bamberg chaired the Potato CGC. We hosted foreign visitors Dr. Akio and Miyako Miyamoto from Obihiro University in Japan and visitors included foreign agriculture students from Colombia, Georgia, Turkey and Brazil (↓).

Two local students learned germplasm concepts and techniques as summer workers.

Because we are active in professional associations, a broad spectrum of potato researchers are familiar with project staff. Thus, we receive numerous contacts for advice on how to specialize germplasm and the best germplasm-handling techniques.

Complete germplasm documentation and details about technology, outreach, administration, and staff publications are readily accessible at our website.

IMPACT STATEMENT

In recent years breeders have engaged in the revolutionary remaking of potato as a diploid inbred crop. This is only possible because haploidizing technology and selfing mutants were both discovered in NRSP6 germplasm-- *by NRSP6 staff*. And NRSP6 further supported the effort in the current project term by testing techniques and importing valuable new stocks. The ploidy manipulation technique that resulted in Yukon Gold was also developed with NRSP stocks--*by NRSP6 staff*. Wisconsin cooperators isolated and incorporated the gene providing durable resistance to late blight from a wild species that had been collected in Mexico and preserved and studied in the genebank long before its potential was recognized. Washington state collaborators incorporated potent nematode resistance. In 2017, Idaho collaborators reported incorporation of resistance to greening (responsible for 10-15% waste)-- *discovered by NRSP6 staff*. Cooperators used NRSP6 stocks to develop breeding stocks resistant to verticillium and scab, and donated those back to the genebank. NRSP6 staff helped Oregon State researchers identify germplasm with strong resistance to nematodes. We produced custom hybrids and propagules to help Industry partners breed lines with much greater levels of an anti-appetite compound aimed at reducing obesity. At least 70% of named US cultivars have our exotic germplasm in their pedigrees. For example, in Wisconsin, of the past 8 cultivar releases from the breeding program, 6 have wild species germplasm as parents obtained directly from NRSP6 (see detail below). NRSP6 staff bred cold tolerant families from which a new cultivar, Winay, was released in 2018 in Peru. Sequencing the potato genome depended on the use of genetic stocks from NRSP6 developed by cooperators at Virginia Tech. The revolutionary intragenic Innate potato lines from Simplot in Idaho were developed through the use of exotic germplasm from NRSP6. Two new potato pests—Zebra chip and *Dickeya*-- have become very serious in recent years. In the current NRSP6 project, we are cooperating with state and federal scientists in Colorado, Texas, New York, and Washington state, screening for and finding potent resistance in exotic germplasm from NRSP6. Folate deficiency causes severe birth defects. With help of NRSP6 staff, state scientists from Oregon identified wild species selections and custom hybrids available only from NRSP6 with high folate and a way to make screening for folate much easier. All these advances would not have been possible using germplasm in the common breeding pool. They needed to be accessed from exotic germplasm. And that exotic germplasm is *only* available in the USA from NRSP6. The use of NRSP6 germplasm by stakeholders has been very robust in the past, increasing knowledge and breeding products that have had a great positive impact on the crop-- and this process is increasing in the current project term. Each of the three US cultivars published this year in American Journal of Potato Research in 2018 have wild species originating at NRSP6 in their pedigrees. The cultivar Atlantic is a good example of the how the long-term job of genebanking needs perpetual support. This cultivar released in 1976 has in its pedigree *andigena* PI 205624 (imported 1953) and *chacoense* PI 175446 (imported 1949). It has been the parent of numerous additional important cultivars, and in 2018 was still in the top 10 of certified seed acres in 2018 in USA and Canada. This huge benefit to US agriculture was possible because Atlantic parents were imported and preserved for breeding use at its very start of the genebank 70 years ago.

An additional useful sketch is found in the genebank interview in the Badger ComonTater and other public outlets found on the “In the News” page on the NRSP6 website.

WORK PLANS / STAFF & FUNDING / ADMINISTRATION

Continue the service program to acquire, preserve, classify, and promptly distribute high quality germplasm and data to all requesters. We will endeavor to say "yes" to requests for custom service and advice whenever we are able.

Continue study of status and dynamics of genetic diversity: Core collection, cogs, how best to collect from the wild. Continue participation in "teaching" activities by hiring summer student interns who learn about potato science and help us explore promising new research and technology ideas.

Continue service to industry partners that has been attracting their strong support, and similarly maintain strong ties with our sister genebanks around the world.

Continue developing germplasm-use technology like big-tuber mutants, double pollination, and look for more efficient ways to evaluate germplasm, like specialized tuber-generating growth chambers.

Continue screening for traits of high priority to both producer and consumer.

PUBLICATIONS

Many other scientists are publishing research that directly or indirectly originated from NRSP6 stocks. The search below in Digitop produced hits which the reader can regenerate. Staff publications (for 2019 and previous) which give details on the initiatives summarized above can be readily accessed through the personnel links for Bamberg, Spooner, and Jansky at the genebank website.

The search below does not catch cultivars, breeding stocks, and genetic stocks, which have some 900 particular names to search, or are *tuberosum* and therefore more likely to be of independent origin. Note that even when the publication is of foreign origin, and the researcher probably received materials from another genebank, that foreign genebank may have originally received those materials from USPG. Since potato research and breeding is a slow process, materials published in 2018 could, of course, have been ordered many years previously. Similarly, these articles may only cite previous work with exotic species as related background information published by others, not because they were the materials used in the present experiment. The result for 2018 is **134 papers**.

Keyword Anywhere(Solanum) AND Keyword Anywhere(abancayense or acaule or achacachense or acroglossum or acroscopicum or aemulans or agrimonifolium or ajanhuiri or alandiae or albicans or albornozii or ambosinum or andreanum or arnezii or astleyi or avilesii or aymaraesense or berthaultii or blanco-galdosii or boliviense or brachistotrichum or brachycarpum or brevicaule or buesii or bukasovii or bulbocastanum or burkartii or cajamarquense or canasense or candolleanum or capsicibaccatum or cardiophyllum or chacoense or chancayense or chilliasense or chillonanum or chiquidenum or chomatophilum or circaeifolium or clarum or coelestipetalum or colombianum or commersonii or contumazaense or curtilobum or demissum or doddsii or dolichocremastrum or edinense or edinense or ehrenbergii or etuberosum or fendleri or fernandezianum or flahaultii or gandarillasii or garcia-barrigae or gourlayi or guerreroense or hintonii or hjertingii or hondelmannii or hoopesii or hougasii or huancabambense or hypacrarthrum or immite or incamayoense or infundibuliforme or iopetalum or irosinum or jamesii or juzepczukii or kurtzianum or laxissimum or leptophyes or leptosepalum or lesteri or lignicaule or limbaniense or lobbianum or longiconicum or macropilosum or maglia or malmeanum or marinasense or matehualae or medians or megistacrolobum or michoacanum or microdontum or minutifoliolum or mochiquense or morelliforme or moscopanum or multidissectum or multiinterruptum or nayaritense or neocardenasii or neorossii or neovalenzuelae or okadae or oplocense or orocense or orophilum or otites or oxycarpum or palustre or pampasense or papita or paramoense or pascoense or paucijugum or paucissectum or phureja or pinnatisectum or piurae or polyadenium or polytrichon or raphanifolium or rechei or sambucinum or sanctae-rosae or sandemanii or santolallae or scabrifolium or schenckii or soestii or sogarandinum or solisii or sparsipilum or spegazzinii or stenophyllidium or stipuloideum or stoloniferum or subpanduratum or sucrense or sucubunense or tarijense or tarnii or trifidum or tundalomense or tuquerrense or ugentii or velardei or venturii or vernei or verrucosum or violaceimarmoratum or weberbaueri or yungasense or goniocalyx or stenotomum or andigenum or andigena) AND Keyword Anywhere(USDA and Solanum and tuberosum)(DATE=2018-2018).