ANNUAL REPORT
FY 2015

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	Secretary (2016)	C. Yencho
Western Region		D. Holm
North Central Region		D. Douches
Northeastern Region	Vice Chair (2016)	W. De Jong
Administrative Advisors		
Southern Region		C. Nessler
Western Region		L. Curtis
North Central Region	Lead AA	R. Lindroth
Northeastern Region		E. Ashworth

United States Department of Agriculture		
ARS		
Technical Representative	Chair (2016)	R. Novy
National Program Staff		P. Bretting
		G. Wisler
Midwest Area		R. Matteri & P. Simon
NIFA		A. M. Thro
APHIS		J. Abad
NRSP-6 Project Leader		J. Bamberg
Agriculture & Agrifood Canada		B. Bizimungu

PERSONNEL CHANGES

Chuck Brown, USDA/ARS technical rep stepped down after 16 years on the committee. He was thanked for his service in a resolution in the NRSP-6 TAC minutes of the June 23-24 TAC meeting at Sturgeon Bay, and awarded a plaque at the meeting of the Breeding and Genetics section of the Potato Association of America on July 20 at Portland Maine. R. Novy, USDA/ARS of Aberdeen, ID is the new ARS technical rep.

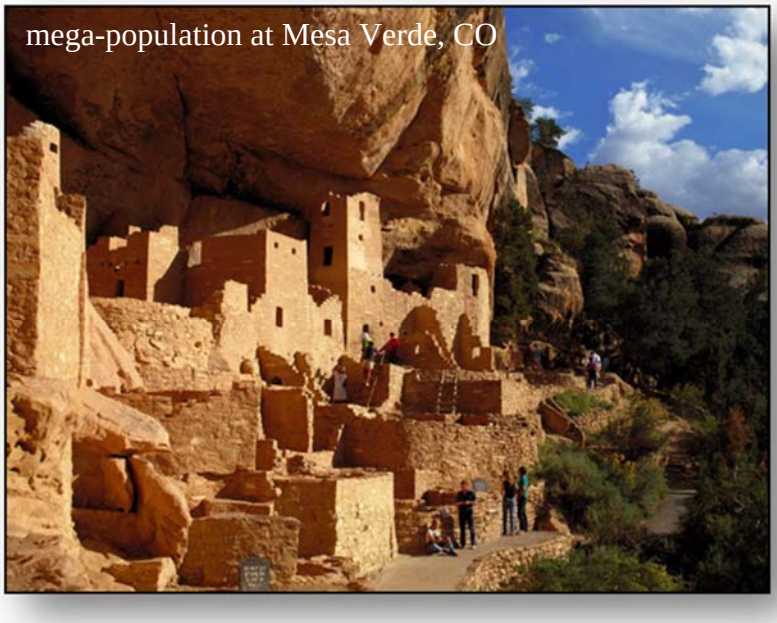
PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. Acquisitions and associated work

In 2015, we collected 17 germplasm accessions from Arizona, with the support of K. Williams of the USDA Plant Exploration office at Beltsville. Local cooperators joined the Sturgeon Bay team this year. In particular, we began a research collaboration with Utah colleagues seeking to collect for genetic evidence that ancient Native Americans moved potatoes. We found robust populations in places never previously reported: Near the Grand Canyon for *S. jamesii*, and at the northwest limit of the range along the Mogollon Rim for *S. fendleri*. A detailed trip report is available on request and on GRIN. We also sought and received 3 new clones of adapted breeding stocks from cooperators (LUMPERS, CIKLAMEN and RH89-039-16).

New collecting partner anthropologist Lisbeth Louderback (center) joins genebank collectors John Bamberg, Alfonso del Rio, Charles Fernandez and Ingrid Bamberg at an *S. jamesii* site near the Grand Canyon, Sept 18, 2015.

Two manuscripts were prepared describing the accumulation of genetic diversity resulting from 25 years of intensive collecting in the southwest USA, and the composition of core collections of these species, including the discovery of a "mega population"-- a single location that contains most of the total genetic diversity known in the region.


mega-population at Mesa Verde, CO

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 2015, 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 continued work on monographs that will fully document the taxonomic reduction of the genebank's holdings to about 100 species. Taxonomic status was assessed on all stocks grown. This year we started planning a project to grow a sprig from each accession for a color scan to attach to the GRIN record. A tentative plan to move the PTIS herbarium to UW-Madison has also been made.

C. Preservation and Evaluation. About 4,000 individual field plots, greenhouse and screenhouse growouts were done locally and at the HARS research farm at Hancock, WI.

1. Propagation: In 2015, 231 accessions were increased as botanical seed populations and 2928 clonally (based on 976 *in vitro* clones being transferred three times each).

2. Germplasm health monitoring: We did 756 PSTV tests, 380 PVX tests, and had Agdia test 105 clones for the six common potato viruses.

3. Characterization: We did 1532 germination tests, 26 ploidy evaluations and 33 tetrazolium seed viability assays. We demonstrated that some seedlots that have very low germination by conventional methods are actually highly viable if germination is nursed *in vitro.*


In vitro germination of recalcitrant seedlots

4. Evaluation and Technology:

Hybrid technology: With Kemin (IA) cooperators, we created exotic hybrids only possible by embryo culture, and tested novel interspecific families with the ability to self, thereby making populations with full segregation for detecting QTLs for marker-assisted selection mapping.

Peru connection: With Peru cooperator J. Arcos and J. Palta of UW, made crosses of various elites for wart, drought, frost, late blight, tuber calcium for Puno, a major center of potato production and breeding in Peru. Puno is also a place with widespread and regular production challenges (especially frost, as shown at right).

Heat stress: With ARS cooperators in Parlier, CA, re-screened 2014 selected tolerant clones.

Egg-yolk specialty potatoes: With cooperators Curzio C. of Seedsavers, D. & I. Douglass and L. Zotarelli of UF, K. Haynes of ARS Beltsville, R. Lozano UMN, D. Holm of CSU, and T. Wagner of WA, replicated field grow-out of all orange flesh *Criolla* cultivar prospects we and others selected; continued field evaluation of elites, taste tests, recurrent selection. Although not the classic Colombian form, a red skinned Criolla might have particular appeal in the USA, and Peruvians also consider this combination attractive.

Protein: With Simplot cooperator initiated high protein screening project.

Genotyping genebank holdings: With Frito Lay initiated GBS of 700 cultivars and breeding stocks and prepared materials for joint work on tuber calcium. With Chinese cooperator initiated GBS of most of the genebank wild species accessions. With MSU and CIP cooperators initiated SNP genotyping of most genebank named cultivars. This promises to be a tremendous tool to show us hot spots of genetic diversity (core collections), which should lead to more efficient collecting, preservation, and evaluation of germplasm.

Core collections and other intra-specific groupings: With MSU cooperator screened all species *S. demissum* pops for late blight and started AFLP characterization. Started screening species *S. cardiophyllum, ehrenbergii, commersonii* for tuber traits and DNA markers. With ARS cooperator in WA, wrote paper on power of intuitive visual classification to predict groups within species with similar traits.

Folate and Nematode: With Oregon State cooperators continued evaluation and selection projects for folate improvement and resistance for Colombia Root Knot Nematode.

Remote grow-outs: With UC Davis, conducted remote winter greenhouse tuber grow-out to expand our capacity by using a location that requires less fuel to heat. With potato grower in Hawaii, started winter grow-out tests for advance field evaluation of new (wild x cultivated) species hybrids.

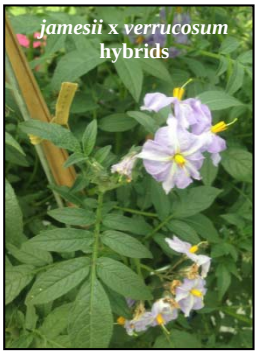
Tuber freezing resistance: Discovered first reported significant tuber freezing survival. If we can dissect the physiology and apply it to other germplasm, it might lead to an efficient long-term germplasm storage tool.

Field tuber adaptation: We discovered how to make large field tubers of *jamesii* and related speciesm which typically have only marble-sized tubers, or none at all in Wisconsin fields. This should allow screening for tuber traits that has previously been possible only in labor and resource-intensive winter greenhouse pot propagation.

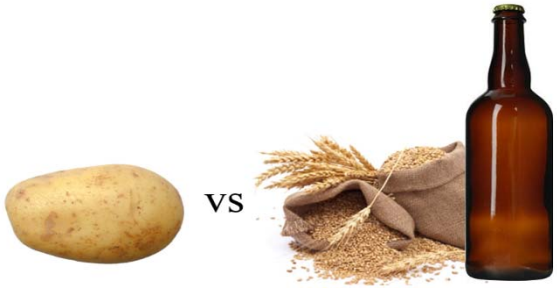
Zebra chip: With USDA/WA cooperator made hybrids between *bulbocastanum* clones which were found last year to be highly resistant to psyllids and evaluated all *verrucosum* pops (more breeding friendly), finding two very resistant.

Wart: With Canadian cooperator A. Murphy, tested new *S. ajanhuiri* hybrids in NL.

Using *S. jamesii*: With collaboration of A. Yermishin of Minsk, crossed all available germplasm of *S. verrucosum* with *S. jamesii*, identifying best bridge-species mothers and obtaining the first 6 true *jamesii* hybrids confirmed by SNP analysis in cooperation with D. Douches at MSU.



Potato beer. Explored feasibility, achieving high quality product. Began investigation of enhanced nutritional qualities, economic impact, characteristics of optimal germplasm. Potato beer has exceptional flavor and smoothness. Beer is a major food outlet in the US. If potato captured some of that market, we would make a significant impact on sub-optimal potassium intake (for example). With the juice of one potato per bottle, exclusive potato beer consumption in the US would require the entire annual potato crop.



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 2015, distributions were typical: 211 domestic orders to clients in 34 states and 13 foreign orders to 10 other countries. About 1/3 of the domestic orders are for breeding and genetics, 1/3 for home gardeners, and remainder 1/3 for pathology, physiology, entomology, taxonomy and education.

In 2015 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). We now only offer tubers of wild species by special order.

	Units of Germplasm Sent[1]							
Category	Seed	TU	IV	DNA	Plants	Herb	Total	PIs
Domestic	2101	2918	1846	1203	2721	0	10789	6405
Foreign	312	44	247	0	0	0	603	412
Total	2413	2962	2093	1203	2721	0	11392	6817

[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), Herb = Herbarium Specimens/(1).

E. Outreach

Trip to Peru in March solidified program for cooperative activities in Puno. Met with FAS, INIA, CIP, and NGOs who are interested in participating in comprehensive germplasm evaluation and development on the Altiplano.

Hosted NRSP-6 TAC meeting. Chaired Potato CGC and AJPR Editorial Board meetings.

Volunteered presentations with published abstracts: Four at PAA in Portland, ME plus one at PAG in San Diego. Invited presentation with published abstract: Society for *In Vitro* Biology conference on June 3 in Tucson. Accepted full paper in In Vitro Cellular & Developmental Biology – Plants with M. Martin (UW), J. Abad (APHIS), M. Jenderek and J. Tanner (ARS, CO), D. Donnelly (McGill, Canada), AMK Nassar (Egypt), R. Veilleux (Virginia PI), R. Novy (ARS ID).

Badger Common'Tater feature story on the Genebank 67(11) p. 20-25.

Hired and managed three undergrad students as summer interns with research projects.

Maintained all US potato germplasm records in GRIN.

All germplasm documentation, and details about technology, outreach, and staff publications is available at our website: http://www.ars-grin.gov/nr6/.

IMPACT STATEMENT

In 2015, seed increase success and distributions were steady, supporting the needs of the nation and world for resources to genetically improve the potato crop.

As the most consumed and most valuable US vegetable, potato substantially influences the farm economy and environment in many states. High value-added processing and high and regular consumption gives potato significant impact in all states with respect to the food economy and citizens' health.

Because potato has more useful exotic germplasm than any other crop, there is much activity in federal, state, and private breeding and research programs using genebank stocks. Potato is a high input crop with many opportunities for improvement that can be addressed by germplasm. Potato is a prohibited import crop, so genetic resources already in the US genebank are the only ones readily available to US germplasm users. Continuing restrictions on international germplasm collecting and sharing make what we already have at NRSP6 even more precious. NRSP6 is the premier potato genebank in the world, and the only program in the nation responsible for providing these potato genebank services.

The payoff in funding the genebank is in discovering and deploying traits that are useful to the public and the industry. We participated in successful selection of better stocks for golden flesh, frost resistance in Peruvian highlands, folate, potassium, resistance to tuber greening, glycoalkaloids, and a natural appetite suppressing protein. New cultivars and releases published this year: Germplasm releases for Early blight resistance, Sierra Rose, and Peter Wilcox. They all have NRSP6 exotic germplasm in their pedigrees, including species *S. andigena, phureja, stenotomum, palustre, bulbocastanum, stoloniferum, edinense.*

Salary and travel support plus cash gifts from industry totaled over $45K in 2015.

The ability to efficiently evaluate traits is rapidly improving. We are on the brink of a leap forward in breeding through molecular markers and genetic technology. Potato is an increasingly important world food. Climate is changing, and health issues and their economic impact are increasing in our aging population. Because of these factors, there has never been a more important (or exciting) time to be involved in improving potato through mining the rich deposits of traits in the US Potato Genebank.

WORK PLANS / STAFF & FUNDING / ADMINISTRATION

In FY16, we plan to 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.

We plan to continue to build our program in the area of genetic diversity management research (making use of the new, more powerful DNA markers now available), collecting research (predicting sites likely threatened by climate change), and benefit sharing collaborations with Andean germplasm donor countries (in particular, the successful frost, drought, wart, tuber calcium breeding effort in Puno).

We expect to 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. This has resulted in students participating in germplasm collecting, formal presentations at PAA, and authorship on peer reviewed publications. Keeping current with potato science and rapport with scientists will be maintained by service as editor of *American Journal of Potato Research*, and participation in the Potato Association of America.

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

We intend to seek opportunities to evaluate and deploy germplasm in ways that impact the consumer, notably with respect to nutritional traits, thus enhancing the reputation, demand, and positive health and economic impact of the potato crop on society.

We expect to continue and expand approaches to evaluation and technology that multiply information gathering:

1. Multiple data collection schemes for a single grow-out, or "multiplex" testing.
2. Synergistic cooperation with specialists in various disciplines, and Latin American projects for benefit sharing and developing systems for testing germplasm that mitigates impact of climate change.
3. Testing for links between easily assessed traits and more difficult traits.
4. Making use of our *in vitro* facilities and expertise to investigate microbial bioassays and selecting agents.
5. Characterizing visual (cog), genetic, geographic, and trait differences within species as predictors of germplasm application.

6. DNA-based tests for assessing genetic diversity with respect to collecting and preservation techniques, and climate change.
7. Exploring use of CETS phytotrons to allow precise and controlled generation of wild species tubers for efficient screening, and propagation of cultivars for evaluation for production in different environments.

PUBLICATIONS

Many other scientists are publishing research that directly or indirectly originated from NRSP6 stocks. Publications that mention potato species (both old and new taxonomy) are likely to have such a connection to USPG germplasm and service. The search below produced hits which the reader can regenerate independently, or which can be accessed through our website: http://www.ars-grin.gov/nr6.

Staff publications (for 2014 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 2014 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.

Digitop > browse by type: Databases > AGRICOLA > (log in) > cut and paste string below into "simple search" box > click "go"

This hits records in Agricola or CAB abstracts: 172 hits from this query in Agricola for CY2015

Solanum and (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 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 or (USDA and "Solanum tuberosum")) (doc-type:Articles or doc-type:Books) pub-year:2014