

ANNUAL REPORT

Calendar Year 2011 with updates through March 2012

NRSP-6: UNITED STATES POTATO GENE BANK

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	Chairman (2012)	J. C. Miller, Jr.
Western Region	Vice-Chair (2012)	D. Holm
North Central Region	Secretary (2012)	D. Douches
Northeastern Region		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	C. Brown
National Program Staff	P. Bretting
	G. Wisler
Midwest Area	L. Chandler & P. Simon

NIFA

A. M. Thro

APHIS

J. Abad

NRSP-6 Project Leader

J. Bamberg

Agriculture & Agrifood Canada

B. Bizimungu

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. Acquisitions and associated work

A genebank team re-collected spots known to be highly diverse in AZ, and found some new, totally unreported robust sites for *jamesii* in NM. The final days were spent collecting the first live *fendleri* from the TNC land in the Davis Mts of west TX, and also rediscovering *jamesii* there. This made 32 new accessions for the genebank. We have been offered to lead an expedition accompanied by a film crew in fall 2012.



S. jamesii near
Silver City, NM



A. del Rio toward
Mt. Livermore,
TNC preserve,
Davis Mts.,
W Texas

Fourteen new clonal stocks were imported-- 10 from Spain, two from Columbia, one from Peru, and one from Canada. Seventeen new populations of *S. microdontum* were added. Two new USA *jamesii* collections were collected and donated by D. Kinder, professor of medical chemistry at Ohio Northern University (anticancer interest). Three named *papa criolla* orange fleshed selections were donated by C. Quiros (CA).

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 2011, informing them of new stocks of true seed, tubers, in vitro plantlets, or herbarium samples.

B. Preservation and Evaluation

We increased 217 seed populations, performed 500 PSTVd tests, 1433 germination tests, 31 ploidy determinations, and 30 tetrazolium seed viability tests. Renovation of the E greenhouse range last fall, along with improved potting techniques and fertilization regime is supporting good seed increases.



Regular need to monitor germination on over 5,000 populations



New greenhouse skin, wiring and controls in fall 2011 provides...



... better environment for abundant fruitset

With help of cooperators, we made progress evaluating germplasm in several ways.

We selected orange-fleshed stocks from hybrids of *S. phureja* based on taste, appearance and cooking quality evaluated by a native Colombian (FL) familiar with the ideal for traditional *papa criolla*.



“Golden” project for orange flesh using Colombian *S. phureja*

With A. Goyer (OR), we identified cultivated and wild species with multiple times the folate levels of standard cultivars. We have begun the process of fine screening, and creating hybrids for breeding and MAS. The often inadequate intake of folate impacts a broad range of serious physical *and mental* diseases.



some *S. boliviense* pops exhibit tremendous levels of tuber folate

The cooperative project with Kemin (IA) continued to make surprising gains, this year again nearly doubling the previously highest known concentration of an anti-appetite enzyme in potato tubers.

We continued evaluation of *microdontum*, a species with a remarkable array of useful traits, this year doing work to show that resistance to illuminated tuber greening is highly heritable.



Testing heritability of tuber greening in *S. microdontum* hybrids

In cooperation with C. Brown (WA) we selected yellow-fleshed clones from populations known to have low sugars, which he and colleagues selected for those able to make a processed product not dependent on high-acrylamide frying conditions for acceptable color.



Natural color can result in golden chips without much acrylamide

Work continued with cooperators at the International Potato Center (CIP) at Lima Peru, and J. Palta (WI) to better understand and exploit the great yield and quality increases resulting when some native cultivars are supplied with extra fertilizer calcium.



Cooperative research plots in Peru

We produced tubers on plants selected for high nutrients and antioxidants, to which Titanium or Water sprays had been applied pursuant to testing the effect of Ti “hormesis”.

Short day winter California field plots (Oct – Jan) were tried, resulting in some success in production of field tubers of wild species that do not form at all in the field at Sturgeon Bay.

Some individuals have severe, even life-threatening allergic reaction to uncooked potato protein. We began investigating the potential for testing a



spectrum of germplasm for greater or lesser allergenicity.

The tetraploid, purple-flowered wild potato native to the USA, previously *S. fendleri*, has been lumped with several Mexican species of series Longipedicellata to a single *S. stoloniferum*. When over 400 populations of coded randomized potted plants were physically clustered by only a quick *a priori* impression, groups with high affinity to previously-named *fendleri*, *stoloniferum* and *polytrichon* emerged. We demonstrated that volunteers of widely varying familiarity with potato have no difficulty in making an instant, accurate visual classification, and every population originating from the USA is always identified as the *fendleri* form. Thus, visually perceived differences in these forms that were previously represented as species are not imaginary. The *fendleri* form clearly differs in flowering duration, tuber initiation and yield. We conclude that the tetraploid Longipedicellata of the USA are exclusively of the *fendleri* form, and that the loss of this name reduces practical information by obscuring its distinction from the *stoloniferum* and *polytrichon* forms of Mexico.



USA wild tetraploid populations are all the *fendleri* form, always distinct from their *stoloniferum* and *polytrichon* Mexican relatives

We expanded work on the *Microdontum* Multifaceted Project (MMP) by identifying 1741 informative AFLP loci for help in selecting a core collection. AFLP loci were treated as though they were traits, with the banded condition considered to be the desired state. At least one band unique to a population was present in 45 populations, and these 45 populations together captured 98% of all bands. Adding another 14 populations for a total of 59 captured all bands. This core set was assessed for whether it encompassed those populations known to have useful traits, including nutritional and quality components; and disease, stress and pest resistances. As with AFLP bands, all 25 of the most desirable phenotypic traits were also found in populations in the core set of 59 populations. These

AFLP markers may also reveal the influence of eco-geo parameters, and introgression from other species.



S. microdontum is an ideal candidate species for various types of genebank study

C. Classification

This year David Spooner did research on: 1) a taxonomic monograph of cultivated potato, 2) a test of taxonomic predictivity of potato taxonomy using soft rot as a test case, 3) a test of taxonomic predictivity of potato taxonomy using virus Y as a test case, 4) A DNA-based analysis of taxonomic relationships in the wild potato group *Solanum* series *Conicibaccata*, 5) a summary of the use of field work for taxonomy, 6) a report of the development of a new technique (SSCP analysis) for separating allelic variants cheaper and more accurately than by cloning, 7) a geographic information systems analysis of the discovery of *Solanum morelliforme* in South America, 8) a summary of taxonomy in *Solanum* series *Lycopersicon*, the sister group of potato.

D. Distribution

The volume and types of stocks sent to various consignee categories are summarized in the table below. NRSP-6 distributed 197 domestic orders to clients in 34 states of the USA and 20 foreign orders to 12 other countries. About ½ of domestic orders are for breeding and genetics, about ¼ for home gardeners, and the remaining ¼ for pathology, physiology, entomology, taxonomy, educational, etc.

Category	Units of Germplasm Sent ¹								PIs
	Seed	TU	TC	IV	DNA	Plants	Herb	Total	
Domestic	2,001	0	2,636	673	0	513	11	5,834	3,910
Foreign	794	0	0	349	0	0	0	1,143	526
Total	2,795	0	2,636	1,022	0	513	11	6,977	4,436

¹ Types of stocks sent/(number of seeds, tubers or plantlets per standard shipping unit): Seed= True Seeds/(50), TU = Tuber families/(12), TC = Tuber Clones/(3), IV = *in vitro* stocks/(3), DNA = dried leaf samples/(1), Plants = rooted cuttings /(1), Herb= Herbarium specimens/(1).

E. Outreach

See Section 6. for genebank research published on a variety of issues. An agenda brief on NRSP-6 progress was sent to all regional association spring meetings, and essentially makes up the Impact Statement below.

Visitors: The genebank hosted the annual national meeting of NRSP-6 TAC in July 2011. We cooperated with Master Gardeners to teach third grade students of the local private and public schools about the diversity of potatoes and plant a potato garden they harvested in the fall. This taught students where their food comes from and about genetic diversity. Dr. M. Srivastav, Senior Scientist at the Indian Ag Research Institute in New Delhi, India toured the genebank, as did a delegation of nine potato specialists from Guizhou province, China (hosted by J. Palta, WI).

Bamberg continued as Editor in Chief for the American Journal of Potato Research, and Chair of the USDA/ARS Potato Crop Germplasm Committee.

IMPACT STATEMENT and Regional Meeting Agenda Brief

In 2011, we were particularly successful in the number and yield of seed increases, and orders for germplasm remained strong. We uploaded much evaluation data on tuber calcium and antioxidants to the public internet database.

The payoff in funding the genebank is in discovering and deploying traits that are useful to the public and the industry. We added four new golden-fleshed potatoes to the collection, and selected several from within the genebank. Working with cooperators from WA and OR, these selections were shown to allow the production of chips and fries with the desired

yellow color, but much reduced levels of the toxin acrylamide. We added to the genebank the clone with phenomenal levels of total antioxidants—as high as leafy green vegetables—which we selected with help of cooperators in TX and WA. Our work with cooperators in Peru continued to make progress on identifying germplasm which responds to calcium applications with better yield, tuber quality, and frost resistance. Work continued on the project to do multiplex tuber testing of the species *microdontum* which has a remarkable array of useful traits, including anti-cancer components. This year we tested the 94 populations of that species for tuber greening, finding some with very strong resistance. S. Jansky tested powdered tuber samples of 400 cultivars and 30 wild species which we provided for analysis of starch types, pursuant to a potato with a lower glyceamic index. Continued work with a cooperator in IA resulted in identifying germplasm with more than 5-fold the natural appetite suppressing protein of standard cultivars—potentially a significant tool for addressing obesity. With an OR cooperator, we found levels of folate in exotic wild and cultivated species with over 5-fold that of standard cultivars, showing that potato could be bred to become a significant dietary source of this vitamin-- which impacts birth defects, cancer, heart disease, and mental health. We continued exploring for germplasm with higher potassium—a nutrient essential for preventing stroke and maintaining bone and muscle with age, but present at much below the optimal levels in the US diet.

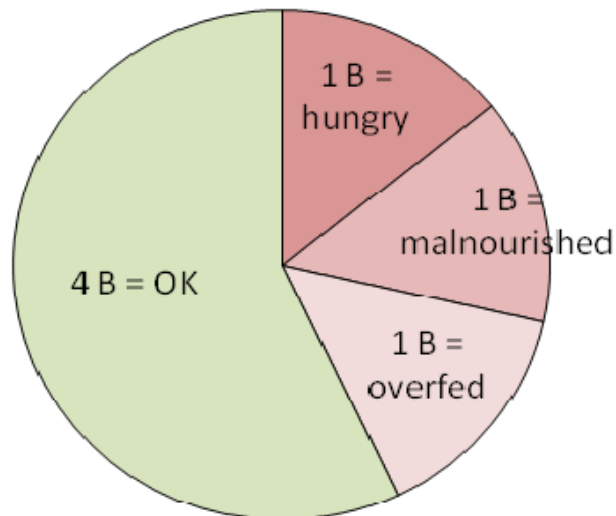
We continued work on improving germplasm management. We again collected germplasm in-country, finding populations at sites never before reported or collected in AZ, NM and TX, and we have already identified two novel mutants in these materials. These and similar USA stocks were used as research models to find more efficient collecting methods. For example, we used AFLPs to identify certain sky-island mountain ranges in AZ with particular genetic diversity, and prioritized them for more intensive collecting. We tested winter tuberization trials in Davis and Parlier, CA.

We added about \$25K in industry support for 2011. We already have a promise of \$20K from two companies, and reasonable hope for significant additions to that from two more in 2012.

Of the 7 billion people on earth, one billion lack enough calories, one billion have enough calories, but are hurting for lack of essential nutrients, and another billion are overfed (The Economist, Feb18, 2012). NRSP6 collaborators are doing work that impacts each of these one-billion-man problems.

Nearly half of the world's 7 billion people have some kind of nutritional challenge

(and potato germplasm can address them all)



Stroke, cancer and obesity costs in the US are at least 100 times that of the total annual farmgate value of the potato crop, so we conclude that the prospect of making a significant impact through nutrition compares favorably with using germplasm to increase yield or reduce production costs. However, a more nutritious potato may also be the best help for producers, if a better potato would increase demand and our competitiveness with other food alternatives.

The genebank's role is two-fold—providing the germplasm and also providing the ideas and technology for how it can be best deployed.

What NRSP-6 does



Service = providing materials and info
(acquire, classify, preserve, evaluate, distribute)

R&D = making the materials and info
more valuable
(and keeps staff in touch with user needs)



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

We suffered a 15% reduction in ARS discretionary budget in FY11. In FY12 the outlook is for an *additional* 51% reduction, resulting in losing ½ of a position (del Rio) and very tight outlook for supplies spending. We do *not* want to respond to this situation by using our fixed cost resources less and getting less done. Instead we have made some staff adjustments to dedicate more work time to priority tasks. We are having more group meetings to better coordinate personnel efforts. We are making use of quite inexpensive summer student interns for routine plant care help, and the top students we have recruited also contribute to research work. Finally, their training is a genebank service contribution. Travel funds will be used only for events where we have particular duties or contributions, or when invited and paid by outside funds. Our planning has become more centered on getting the most, and the most

high impact results from doing the kind of work that we are already efficient at—that is, already have the equipment, facilities, and skills to do at relatively low cost (like making custom tuber samples and hybrids). We have also intensified multiplex tuber testing on the MMP (*microdontum*) project. We are planning, and will deploy a new initiative in summer 2012, dubbed “WOS” for With One Stone. This involves collecting a list of several technical questions (birds to kill) that can be overlaid on a single grow-out (with one stone). Thus, one might grow a set of populations for tubers to be used for a separate purpose, but, at the same time, assess effect of fertilizer application method, temperature regime, planting depth, etc., on tuberization. As already mentioned, particular emphasis on mining nutritional traits will continue. We continue to seek donations from private industry partners, as well as more traditional grants. At this writing, we have at least \$23K committed from industry for 2012. We have an expectation of up to \$15K from a Potato CGC evaluation grant. Beltsville has intention to support our germplasm collecting in 2012, and if that fails, the film company that has asked to accompany us has offered to help.

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