NRSP_temp6: The US Potato Genebank: Acquisition, Classification, Preservation, Evaluation and Distribution of Potato (Solanum) Germplasm

Status: Under Review

Duration	10/01/2020 to 09/30/2025
Admin Advisors:	[William Barker] [Walter De Jong] [J. F. Meullenet] [Joyce Loper]
NIFA Reps:	

Statement of Issues and Justification

Prerequisite Criteria

How is the NRSP consistent with the mission?

[NOTE: An Executive Summary can be found on p. 2 of the attached file "ENTIRE FORMATTED PROPOSAL"]

a. NRSP6 is the only practical source of potato germplasm for US researchers and breeders:

NRSP6 is designated the sole official NPGS project filling the role of working potato genebank for the US. A good way to understand the importance of NRSP6 is to imagine the situation if no genebank was present for an individual researcher wanting to use exotic potato relatives. He would first need to study taxonomic boundaries to understand his material and how it related to cultivars. He would need to determine breeding system, requirements for growth, and interspecific crossing. If it did not exist in the US or he could not find or obtain it from a fellow US researcher, he would need to organize an expedition to Latin America. Since potato is a “prohibited” plant for import, he would have to negotiate APHIS quarantine and wait one or two years. When finally in hand, would he propagate the germplasm disease-free, and advertise it for sharing with all potato researchers worldwide? NRSP6 does and coordinates all these things for the potato research community, avoiding the confusion, inefficiency and costs associated with duplication of these efforts by many individuals. This is not a static process, but must evolve with the advance of science and as needs and opportunities change over time.

b. NRSP6 provides enabling technologies and materials.

Germplasm stocks. As described above, providing the germplasm itself enables advances in potato research and breeding. In the past project term NRSP6 has met this need by freely and promptly distributing materials and doing the associated work that supports these distributions.

Germplasm data. NRSP6 provides users with a central source of current germplasm information: What is available in US and globally, taxonomic relationships, natural origin, characterization and evaluation data with respect to useful traits. To do this, NRSP6 must also develop and maintain acquisition; classification; seed increase, inventory, disease status and distribution data. All of this data pertinent to the needs of germplasm users is available 24/7 online.

R&D for best techniques and tools for germplasm collecting, preservation, and evaluation. The genebank is the focus of NRSP6, but we must keep in mind that the genebank has only a sample of what is available in the wild. Thus, study and appropriate action to make the genebank collection the best it can be is crucial. Diversity is the goal, but while the scope of potential diversity we could collect and keep is virtually unlimited, genebank funding is not. R&D that characterizes diversity richness and enables the most efficient techniques for collecting and preservation is of great importance for our own genebank and others worldwide. NRSP6 has become a world leader in developing such information and tools by examining specific practical questions with DNA markers, often using materials from collecting expeditions organized and conducted by genebank staff.

Custom materials for germplasm evaluation. It would not be appropriate for genebank staff to specialize in any one evaluation discipline. Instead, genebank staff expertise in germplasm genetics and handling is used to devise studies, then select and prepare materials for testing in partnership with various extramural scientists with the specific expertise and infrastructure for generating the data.

How does the NRSP pertain as a national issue?

Rationale

Priority Established by ESCOP/ESS

Challenge 1: We must enhance the sustainability, competitiveness, and profitability of U.S. food and agricultural systems
This can be achieved through lower input costs keeping all other factors steady. Or, quality can improve to support higher prices at the same market share. The optimal scheme for the potato crop is to use germplasm to make gains in all three areas: less input costs, higher yield per area of land, and higher quality. Other initiatives that will contribute to these general

goals are increasing *net* yield by reducing storage losses, and capitalizing on virtual demand by removing the physiological limits to potato production due to the climate, diseases and pests.

Challenge 2 . We must adapt to and mitigate the impacts of climate change on food, feed, fiber, and fuel systems in the United States. Potato is cultivated across a broader range of latitudes than any other major crop. Thus, the effects of climate change could be different in different growing regions, and require the screening for multiple new traits in exotic germplasm which can be incorporated into the crop. Genebank staff are actively working on modeling climate change and predicting impact on *in situ* populations—heat, drought, cold and other stresses.

Challenge 3: We must support energy security and the development of the bioeconomy from renewable natural resources in the United States. NRSP6 does not address this challenge.

Challenge 4: We must play a global leadership role to ensure a safe, secure, and abundant food supply for the United States and the world. This is the heart of what NRSP6 aims to promote. Genetic diversity of the exotics at NRSP6 represents the potential diversity of improvements in productivity, quality and resource use efficiency realized in new cultivars.

Challenge 5: We must improve human health, nutrition, and wellness of the U.S. population. As already mentioned, improved potato has outstanding potential to have a significant health and nutrition impact on a population basis because it already has a regular, high level of consumption across all demographic categories in the US. Compare, for example, to blueberries which have famous levels of antioxidants per serving, but are very expensive, and are eaten only in small quantities and irregularly. Potato has had obvious appeal—it is relatively cheap, good-tasting in many forms, and filling. Because of extensive potato cultivation of potato, reducing the need for chemical inputs in the potato crop through genetic means could significantly reduce the exposure to agrichemicals (manufacture, transport, storage, grower, consumer). Genetic improvements via NRSP6 germplasm are resulting in a more productive, versatile, profitable, nutritious and environmentally safe potato crop.

Challenge 6: We must heighten environmental stewardship through the development of sustainable management practices Research supported by NRSP6 will continue to find ways to make a crop that is more efficient at using fertilizer and water inputs and can naturally resist pests and diseases. That means less impact on the environment through less use of pesticides.

Challenge 7: We must strengthen individual, family, and community development and resilience. NRSP6 can have an impact on primitive farmers in developing countries who could improve their standard of living and maintain their culture because germplasm inputs gave them a more marketable and nutritious crop (by increasing frost tolerance for high altitude farmers, for example). Food security in developing countries often has a favorable influence on political stability, which reduces the money US citizens must spend to maintain international relations and foreign aid. A healthy US populace can also have a higher standard of living due to more productivity and less need to spend the profits from that productivity on insurance, medical care and government intervention programs.

Relevance to Stakeholders

NRSP6 stakeholders are researchers, breeders, those who use their product (producers), food suppliers, and, ultimately, consumers. Here are the reasons why there is a continued need and relevance of NRSP6 service to stakeholders, and why US scientists (and foreign ones) will depend on NRSP6 germplasm more in the future:

1) No other public or private programs have come forward to provide the unique services of NRSP6. Seventy years of public support of this genebank has resulted in the collection of nearly 6,000 items of germplasm for the world's most important non-cereal crop. At least 45% of these are unique.

2) The need for potato research and breeding is increasing. Development of technology has enhanced the quantity and impact of research and publications involving germplasm. There is a US-based international association of researchers devoted to potato with Breeding and Genetics taking a prominent role (The Potato Association of America). There are numerous breeders, hundreds of thousands of seedlings grown for yearly selection, more sophisticated facets of evaluation, and more varieties being released. There is increasing challenge to gather, format and distribute information with the greater speed and detail made possible with advances in data management technology.

3) Acquisition of germplasm from foreign genebanks or directly from the wild is becoming even less practical for US researchers. Other genebanks have faced financial problems or reorganization which has reduced their capacity to maintain availability of germplasm and services. Countries with native potato germplasm to share are doing so less freely due to policies reflecting feelings of national ownership and problematic expectations of "benefit sharing" that have delayed access from Latin America since 2000. So, dependence on raw materials we have in-country at NRSP6 is greater than ever.

4) Potato is listed as "prohibited" by APHIS, making quarantine testing of all imports for one-two years necessary, at an estimated cost of over $4,000 per item. To avoid the wasted time and expense of having quarantine repeatedly process the same material for multiple importers, we need the coordination, information and preservation provided by NRSP6.

5) We need to reduce agrichemical inputs that are costly and may threaten the health of humans and the environment. We need solutions to legal limitations to use of pesticides and water so producers can stay in business. For farmers and consumers, genetic solutions through germplasm are increasingly important.

6) Physiological constraints such as a need for cold tolerance (applied especially to the mountain growing regions like the Andes but everywhere subject to the global cycle of wider weather fluctuations), heat and CO_2 (global warming), water and fertilizer use efficiency (loss of water rights, phosphates in lakes, nitrates in groundwater, energy costs for pumping water and making fertilizer) have increased, as well as a general need to increase the adapted range of potato to production areas where it would increase food security and benefit the world economy. All these point to an increasing need for the "new blood" available in NRSP6 exotic germplasm.

7) Technology has increased the possibilities for germplasm use making it more valuable. Now whole genome sequencing is practical. Targeted genes can be modified by CRISPR technology. The prospects of easily identifying and mining genes from exotic germplasm (reducing the long and expensive process of conventional breeding) makes the service of NRSP6 even more valuable to stakeholders.

Implementation

Objectives

1. Acquire germplasm.
   Comments: Objectives represent the ongoing work of the genebank. When the new project anticipates pursuing particular goals and quantities, those are noted in [brackets]. Latin America. Most of Latin America is currently closed to US germplasm collecting. [We will continue work to better understand the status and vulnerability of the in situ germplasm resource, particularly related to climate change. We will also pursue new opportunities for research-oriented collecting in Peru and Mexico, and expand frost and wart resistance breeding with germplasm donor countries. We will pursue extension of clean tuber seed production systems in Latin American countries that need it to systematically evaluate NRSP6 germplasm.] Collecting in the USA. Annual collection trips will be made to acquire new germplasm and to gather materials for research investigations on collecting methods and the relationship of in situ to ex situ genetic diversity. [We will study diversity within populations in the wild, predictors of patterns of diversity across the range and impact of climate change models. We will vigorously pursue opportunities for cooperation with local botanists.] Germplasm donations. We will continue to survey researchers for their needs, and assess gaps in the collection, then initiate the corresponding imports from foreign genebanks and public and private germplasm developers. NRSP6 staff will continue to evaluate and develop mutants and other selections that will be formally deposited in the genebank. New genetic stocks and families are being developed by others (e.g., mapping populations and inbred lines) and PVPs are expiring. These will increase the need for the genebank as a safe repository and source.
2. Classify germplasm.
   Comments: We will continue to use genetic markers and phenotypic traits to differentiate germplasm into sub-taxa and core subsets that guide germplasm users to the best materials for their work.
3. Preserve germplasm.
   Comments: Objectives represent the ongoing work of the genebank. When the new project anticipates pursuing particular goals and quantities, those are noted in [brackets]. Propagate. Increase seedlots at the rate of greater than 200 per year for a 25-30 year cycle. Conduct in vitro transfers needed to maintain clonal collection viability. Safeguard. Maintain on-site and remote backup collections at the National Center for Genetic Resources Preservation (NCGRP) at Ft. Collins, CO. Maintain health. Continue vigorous, comprehensive testing to minimize the possibility of distribution of diseased stocks. [We will set up two custom growth chambers for isolated tuber production]. Genetic diversity management. DNA-marker-based studies will show us where genetic diversity is concentrated and vulnerable to loss, so we can prioritize stocks for preservation and optimize techniques as needed. [We will continue to test methods of selecting core collections for more efficient germplasm sampling. We will continue DNA-marker-based studies aimed at understanding relative genetic heterogeneity of germplasm subgroups and how this impacts sampling when collecting, preserving and evaluating the germplasm.] Technical research. Studies will be done to improve the efficiency of growing, mating, and storing the stocks, providing results that help the genebank and our clients. [We will... investigate media alternatives and drip irrigation.... continue to systematically test bridge-crossing techniques to bring S. jamesii and similar primitive diploids into the breeding pool... continue breeding toward an ideal universal diploid cultivated tuberosum parent for introgressing diploid exotic wild germplasm... test methods of in vitro embryo rescue.] Records. Maintain local data records and those on-line in GRIN and Intergenebank databases [We will make photographs and tissue samples of the field tubers of the cultivar collection and post them online. We will keep the PCGC Vulnerability Statement document updated and create a Best Management Practices document for gentically modified potato stocks.]
4. Evaluate germplasm.
   Comments: Objectives represent the ongoing work of the genebank. When the new project anticipates pursuing particular goals and quantities, those are noted in [brackets]. Continue screening and characterization for novel traits and novel applications of exotic germplasm. [We will do additional cooperative evaluation and development work on traits discovered/developed in the past project term: anti-appetite and anti-cancer chemicals; nematode, Dickeya, Pseudomonas, CPB, bacterial wilt and Zebra chip resistance; tuber calcium, frost tolerance.]
5. Deliver germplasm and services.
   Comments: Continue the rapid delivery of high quality germplasm and information. Continue to advise on selection of research germplasm, and the most appropriate forms and techniques by which to study or hybridize it. We will continue to produce custom hybrids and form to meet the specialized needs of customers. We will continue to invest time in keeping “in touch” with the science by studying the literature, training students, participating in professional societies and collaborating with many state and federal potato researchers in the US and with our counterparts in potato genebanks abroad.

Projected Outcomes

- Acquire germplasm to expand genetic diversity contained in the US Solanum germplasm collection. Comments: Accomplishments of previous 5-year project serve as an example of expected outcomes: At total of 189 new stocks were added by USA collecting, requests from cooperators, and requests from genebank staff (see Appendix A1 in attached file "ENTIRE FORMATTED PROPOSAL" for details).
- Classify accessions with species names which will serve as stable identifiers, and promote efficient utilization. Comments: Accomplishments of previous 5-year project serve as an example of expected outcomes: Species names were assigned to all new accessions. Taxonomic studies using both molecular and classical techniques were employed to determine stable species boundaries, condensing the over 200 species names of the past to less than 100 (Appendix A2 in attached file "ENTIRE FORMATTED PROPOSAL" for details).
- Preserve NRSP6 germplasm in secure, disease-free, and readily available form. Comments: Accomplishments of previous 5-year project serve as an example of expected outcomes: The genebank now has nearly 6,000 stocks as seed populations and clones. These were preserved with maximum genetic integrity in viable, disease-free form available for distribution. This effort included maintenance of data, performing seed and in vitro increases, purity tests, disease tests, germination tests, chromosome counts, field grow-outs, and better scheduling of pollination to catch parents at their peak. (see Appendix A3 in attached file "ENTIRE FORMATTED PROPOSAL for details).

- Distribute germplasm, associated data and advice to all researchers and breeders in a timely, efficient, and impartial manner. Comments: Accomplishments of previous 5-year project serve as an example of expected outcomes: Orders greatly increased in the past project term, and were filled within one week of receipt. Details by state and region are presented in Appendix A4 of attached file "ENTIRE FORMATTED PROPOSAL".
- Evaluate the collection for as many important traits as possible. Comments: Accomplishments of previous 5-year project serve as an example of expected outcomes: Unpublished screening data of experiments conducted by cooperators was summarized and uploaded to GRIN. Evaluation initiated by staff and done in-house or with cooperators covered a broad range of topics pursuant to more efficient mining of the value of NRSP6 germplasm. See Appendix A5 for scheme for systematic mining and study of germplasm traits in attached file "ENTIRE FORMATTED PROPOSAL".

Management, Budget and Business Plan

MANAGEMENT & BUDGET

Summary of pursuit of alternate funding The decision to fund FY16-20 at its onset included the proviso "... require committee to investigate alternative funding models & report back to NRSP-RC at midterm review." We did a thorough investigation of the history, current status, and rationale of the project funding, partnership structure, need for its service, and impact. We did not find any new factors in these areas that indicate changing to an alternate model would improve upon what has been working well for 70 years. Regardless, we did do a thorough investigation of all potential alternate sources of funds. We concluded that there are no other substantial and stable alternate contributors ready to take the place of the current OTT funding as NRSP6. Considering the above, the only viable option for this FY21-25 project proposal was to request continuing the current funding for NRSP6. We are content with proposing flat funding again, although this continues the 25-year pattern of serious transitioning away from state support. Twelve leaders including SAES, ARS, and industry potato breeders; RPIS and international germplasm managers and developers; potato farmers; and senior NIFA officials reviewed it. Most of them specifically remarked that transition to alternate funding appears to be impractical and requiring it would damage the program, so unanimously recommended continuing the *status quo* $150K budget.

A detailed review of the history, budget rationale, and resonse to external review comments can be found on page 32 of the attached file "ENTIRE FORMATTED PROPOSAL"

Human resources. Project direction will be accomplished through a Technical Advisory Committee and USDA/ARS National Plant Germplasm System leadership. Local administration is by the ARS Project Leader, ARS and UW staff and associated ARS scientists and administration at Madison. We will: Manage staff time and budget to maximize efficiency and flexibility. Strive to make prudent decisions on what we should do in-house and what should be contracted or purchased. Direct experienced base staff to tasks requiring technical expertise and reserve routine work for part-time staff. Hold regular group meetings to make sure the team is working together cooperatively and safely. Conduct annual self-review of overall project progress each year with local staff, and individual staff performance evaluations. Hold TAC meeting on-site every other year to report, tour facilities, provide "face time" with all local staff, and solicit management input from national experts. Each year prepare the Annual Report (see Appendix C of attached file "ENTIRE FORMATTED PROJECT"), UW Hort Department Professional Activity Report, and ARS Performance Plan Appraisal, as ways to invite feedback on methods, focus and management.

ARS contributions. Associated base research budgets from ARS scientists and various sources of outside grant funds also support technical research, labor, supplies and equipment that directly enhance NRSP6 service See Appendix F of attached file "ENTIRE FORMATTED PROJECT" for details of structure and contributions. ARS administration costs at the Midwest Area and National Levels are also significant. USDA/ARS and USDA/APHIS also provide data management services through GRIN, and for quarantine, respectively.

University of Wisconsin contributions. The University of Wisconsin Department of Horticulture (HORT) will provide lab and office space for on-campus R&D that supports the NRSP6 service, with administrative and secretarial support for Madison personnel provided jointly by ARS and HORT. The University of Wisconsin Peninsula Agricultural Research Station at Sturgeon Bay (PARS) will continue to be the headquarters of NRSP6. PARS will contribute much of the needed facilities and associated resources: 10 greenhouses, 5 large screen houses, office and storage buildings, two labs, field plots, travel and farm vehicles, security and maintenance, utilities (including the major input of heat and light for greenhouses), plus some secretarial service. We will also use greenhouse and field resources at remote locations with cooperators at the UW-Hancock field station. HORT also provides administration of personnel for local state employees and graduate students associated with the genebank. UW provides accounting services for the NRSP6 budget.

Grants and Collaborators. ARS scientists will continue to seek grants and engage numerous state, federal, international, and industry collaborators who contribute expertise, facilities, equipment and funds to joint projects of mutual interest. Project Leader will continue as chairman of the Crop Germplasm Committee, which provides ~$10K in germplasm evaluation funds each year, expressly intended for evaluation of NRSP6 genebank stocks.

No fees for service. Charging fees for services has been suggested several times in the past, but always determined to be impractical and counterproductive because implementation would be costly and complicated, it would depress germplasm distribution and use, and, it would contradict USDA policy of free exchange and perhaps inhibit donations of germplasm to NRSP6.

MRF contributions. NRSP6 is the NPGS working genebank for the top vegetable, so is perpetual in nature and national in scope. About 37% of germplasm distributions go to SAES scientists. For 70 years, the important elements of funding and administration for NRSP6 have developed as a partnership of SAES, USDA/ARS, and UW. Continued significant funding and technical/administrative inputs on a multistate basis are seen as necessary to keep this partnership healthy and maintain this project's impact and efficiency.

Industry contributions: Gifts from private companies prove the practical value of NRSP6, and keep us tuned to the needs of the industry. Such gifts totaled about $44K in the past 5 years. Robust support of this kind will continue to be sought.

BUSINESS PLAN

Plan: The FY21-25 budget proposal is to continue at a base $150K per year. See appendices with History, Budget tables and background details in attached file "ENTIRE FORMATTED PROPOSAL".

Integration

There is a close working relationship among the genebank participants (ARS, PARS, UW). In brief: The Project leadership is composed of ARS employees who must interact with ARS administration and be subject to performance evaluation related to NRSP6 service appointments. ARS administration is part of the NRSP6 TAC. PARS provides the physical location of NRSP6, and coordination between the objectives of the two programs takes place on a daily basis. Local NRSP6 staff are both UW

and ARS employees. Part time staff are UW. ARS staff share equipment and participate in cooperative research with their state HORT peers. Thus, the UW HORT potato research program is fully engaged in NRSP6 project activities pursuant to the enhancement of NRSP6 service. NRSP6 has led the effort to coordinate the activities of world genebanks through the Association of Potato Intergenebank Collaborators (APIC). NRSP6 is a fully-engaged member of the National Plant Germplasm System. Staff attend all meetings of the advisory committee for genebank directors (PGOC) and the committee for the national germplasm management database (GRIN). NRSP6 staff are fully engaged in state potato programs. We participate in scientific, grower meetings, and field days and conduct collaborative research with a view to better understanding the needs of the industry and getting input regarding how NRSP6 can meet them. NRSP6 maintains email contact with 501 active cooperator/germplasm users, a 17% increase over the past project term.

Outreach, Communications and Assessment

Audience and visibility. The primary recipients of our service are breeders and the scientists doing research that supports breeding. We also serve researchers seeking to optimize germplasm management, and home gardeners and non-professional botanists. We have a general educational outreach through brochures, website, and popular press. NRSP6 staff routinely give tours, talks to public school classes and other groups. We give advice on germplasm use technology, or in personal correspondence associated with germplasm orders or cooperative research and evaluation projects.

NRSP6 staff:

- Attract publicity in popular media and communicate to scientists through published scientific research papers involving NRSP6 germplasm.
- Make collaborative partnerships with high-profile national and international potato experts and contribute to scientific meetings.
- Serve in leadership roles in potato research associations and journals (Potato Association of America,*American Journal of Potato Research*, Crop Germplasm Committee).
- Establish an email group and website to keep in regular contact with germplasm users and participate fully with GRIN.
- Extend global outreach and awareness of NRSP6 through involvement in the Association of Potato Intergenebank Collaborators (APIC) and international cooperators on an *ad hoc* basis.
- Train Summer Undergrad Student Interns on mini-research projects and general operations of a genebank. Some such work leads to formal publications.

Engage stakeholders. NRSP6 established an email group and offers stocks and services 3-4 times per year. We will continue to ask Potato Assn of America Breeding and Genetics section members for suggestions on how to improve service each year. Regional Tech reps annually poll germplasm recipients about satisfaction with service. As CGC chair, Project Leader must survey germplasm evaluation needs. We correspond meaningfully with recipients of *each order* to make sure their needs were completely met, ask for suggestions or other ways we could improve service.

Method to measure accomplishments and impacts. The most important documented evidence with which to measure impact is the advance of practical knowledge about germplasm reflected by formal research publications using NRSP6 stocks and the presence of exotic germplasm in pedigrees of new cultivar releases (that practical knowledge transformed into a better crop). NRSP6 publications and uses of stock in new cultivars is documented in Appendix B of the attached file "ENTIRE FORMATTED PROPOSAL".

Communication pieces. Locally generated brochures, web pages, posters at meetings.

Mechanisms for reporting. Annual Report, notes of accomplishments and plans in preliminary pages of annual Budget Requests, and TAC meeting minutes are on the web. NRSP6 has always had the philosophy that the best and only way to catch the attention of germplasm users, communicate effectively with them, and understand their needs is to become their peers by being germplasm users ourselves and vigorously participating in all aspects of the science, including formal research that culminates in publication in peer-reviewed journals. See Appendix B of the attached file "ENTIRE FORMATTED PROPOSAL" for further details.

Literature Cited

Information dissemination. Scholarly publications below from NRSP6 staff.

An additional 765 publications by other users of NRSP6 stocks were cited in the annual reports of the past project term.

Bamberg publications from past 5 years below. Full list at: https://horticulture.wisc.edu/wp-content/uploads/sites/20/2019/01/John-Bamberg-CV.pdf

Kramer, L.J. and John Bamberg. 2019. Comparing Methods of Ploidy Estimation in Potato (Solanum) Species. American Journal of Potato Research 96:419

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del Rio A.H., Obregon C., Bamberg J.B., Petrick J., Bula R., de la Calle F. 2017. Validation of high-quality potato seed production protocol under controlled conditions (CETS System) in cultivated potato species (Solanum tuberosum L.). ALAP Journal 21(2): 71-78.

Cooper, R., and JB Bamberg. 2016. Variation in susceptibility to potato psyllid, Bactericera cockerelli (Hemiptera: Triozidae), among Solanum verrucosum germplasm accessions. American Journal of Potato Research 93:386-391.

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Bamberg, JB and A. H. del Rio. 2016. Accumulation of genetic diversity in the US Potato Genebank. American Journal of Potato Research 93:430-435.

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Jansky, S.H., Charkowski, A.O., Douches, D.S., Gusmini, G., Richael, C., Bethke, P.C., Spooner, D.M., Novy, R.G., De Jong, H., De Jong, W.S., Bamberg, J.B., Thompson, A.L., Bizimungu, B., Holm, D.G, Brown, C.R., Haynes, K.G., Sathuvalli, V.R. et al. 2016. Reinventing potato as a diploid inbred line-based crop. Crop Science 56:1-11.

Chung, Y.S., Palta, J., Bamberg, J., Jansky, S. 2016. Potential molecular markers associated with tuber calcium content in wild potato germplasm. Crop Science 56(2):576-584.

Bruce R. Robinson, Vidyasagar Sathuvalli, John Bamberg, and Aymeric Goyer. 2015. Exploring Folate Diversity in Wild and Primitive Potatoes for Modern Crop Improvement. Genes (Basel). 2015 Dec 8;6(4):1300-14.

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Hardigan, M., J Bamberg, C Robin Buell and D Douches. 2015. Taxonomy and genetic differentiation among wild and cultivated germplasm of Solanum sect. Petota. The Plant Genome 8:1:16.

Bamberg, JB, A del Rio, J Coombs and D Douches. 2015. Assessing SNPs versus RAPDs for predicting heterogeneity in wild potato species. American Journal of Potato Research 92:276-283.

Publications of associated ARS staff:

Spooner: https://horticulture.wisc.edu/faculty-profiles/spooner-publications/

Jansky: https://horticulture.wisc.edu/faculty-profiles/jansky_publications/

Outreach Plan

Audience and visibility. The primary recipients of our service are breeders and the scientists doing research that supports

breeding. We also serve researchers seeking to optimize germplasm management, and home gardeners and non-professional botanists. We have a general educational outreach through brochures, website, and popular press. NRSP6 staff routinely give tours, talks to public school classes and other groups. We give advice on germplasm use technology, or in personal correspondence associated with germplasm orders or cooperative research and evaluation projects.

NRSP6 staff:

Attract publicity in popular media and communicate to scientists through published scientific research papers involving NRSP6 germplasm.

Make collaborative partnerships with high-profile national and international potato experts and contribute to scientific meetings.

Serve in leadership roles in potato research associations and journals (Potato Association of America,*American Journal of Potato Research*, Crop Germplasm Committee).

Establish an email group and website to keep in regular contact with germplasm users and participate fully with GRIN.

Extend global outreach and awareness of NRSP6 through involvement in the Association of Potato Intergenebank Collaborators (APIC) and international cooperators on an *ad hoc* basis.

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Engage stakeholders. NRSP6 established an email group and offers stocks and services 3-4 times per year. We will continue to ask Potato Assn of America Breeding and Genetics section members for suggestions on how to improve service each year. Regional Tech reps annually poll germplasm recipients about satisfaction with service. As CGC chair, Project Leader must survey germplasm evaluation needs. We correspond meaningfully with recipients of *each order* to make sure their needs were completely met, ask for suggestions or other ways we could improve service.

Method to measure accomplishments and impacts. The most important documented evidence with which to measure impact is the advance of practical knowledge about germplasm reflected by formal research publications using NRSP6 stocks and the presence of exotic germplasm in pedigrees of new cultivar releases (that practical knowledge transformed into a better crop). NRSP6 publications and uses of stock in new cultivars is documented in Appendix B of the attached file "ENTIRE FORMATTED PROPOSAL".

Communication pieces. Locally generated brochures, web pages, posters at meetings.

Mechanisms for reporting. Annual Report, notes of accomplishments and plans in preliminary pages of annual Budget Requests, and TAC meeting minutes are on the web. NRSP6 has always had the philosophy that the best and only way to catch the attention of germplasm users, communicate effectively with them, and understand their needs is to become their peers by being germplasm users ourselves and vigorously participating in all aspects of the science, including formal research that culminates in publication in peer-reviewed journals. See Appendix B of the attached file "ENTIRE FORMATTED PROPOSAL" for further details.

Organization/Governance

Literature Cited

Information dissemination. Scholarly publications below from NRSP6 staff.

An additional 765 publications by other users of NRSP6 stocks were cited in the annual reports of the past project term.

Bamberg publications from past 5 years below. Full list at: https://horticulture.wisc.edu/wp-content/uploads/sites/20/2019/01/John-Bamberg-CV.pdf

Kramer, L.J. and John Bamberg. 2019. Comparing Methods of Ploidy Estimation in Potato (Solanum) Species. American Journal of Potato Research 96:419

Bamberg, JB, and G Greenway. 2019 Nutritional and Economic prospects for expanded potato outlets. American Journal of Potato Research 96:206-215.

Bali, S., BR Robinson, V Sathuvalli, JB Bamberg, and A Goyer. 2018. Single nucleotide polymorphism markers associated with high folate content in wild potato species. PloS ONE. 2018 Feb 23;13(2):e0193415. doi: 10.1371/journal.pone.0193415.

Graebner, RC, CR. Brown, RE Ingham, CH Hagerty, H Mojtahedi, RA Quick, LL Hamlin, N Wade, JB Bamberg, and V Sathuvalli. 2018. Resistance to Meloidogyne chitwoodi identified in wild potato species. American Journal of Potato

Research 95:679-686.

Bamberg, J.B. 2018. Diurnal alternating temperature improves germination of some wild potato (Solanum) botanical seedlots. American Journal of Potato Research 95:368-373.

Bamberg, JB, del Rio, A, Jansky, J and Ellis, D. 2018. Ensuring the genetic diversity of potatoes. In: Achieving sustainable cultivation of potatoes No. 26, Vol.1 (Ed. Prof. Gefu Wang-Pruski). Burleigh-Dodds Science Publishers. Chapter 3, pp 57-80.

Bamberg, JB, CJ Fernandez, and AH del Rio. 2017. Extra soil fertilization of mother plants increases botanical seed yield but not long-term germination in wild Solanum (potato) species. American Journal of Potato Research 94:583-587.

del Rio A.H., Obregon C., Bamberg J.B., Petrick J., Bula R., de la Calle F. 2017. Validation of high-quality potato seed production protocol under controlled conditions (CETS System) in cultivated potato species (Solanum tuberosum L.). ALAP Journal 21(2): 71-78.

Cooper, R., and JB Bamberg. 2016. Variation in susceptibility to potato psyllid, Bactericera cockerelli (Hemiptera: Triozidae), among Solanum verrucosum germplasm accessions. American Journal of Potato Research 93:386-391.

Bamberg, JB, A. H. del Rio, D. Kinder, L. Louderback, B.Pavlik, and C.Fernandez. 2016. Core Collections of potato (Solanum) species native to the USA. American Journal of Potato Research 93:564-571.

Bamberg, JB and A. H. del Rio. 2016. Accumulation of genetic diversity in the US Potato Genebank. American Journal of Potato Research 93:430-435.

Bamberg, J.B., Martin, M.W., Abad, J., Jenderek, M.M., Tanner, J., Donnelly, D.J., Nassar, AM.K., Veilleux, R.E., Novy, R.G. 2016. In vitro technology at the US Potato Genebank. In Vitro Cellular and Developmental Biology – Plants 52:213-225.

Bamberg, JB, AH del Rio and RA Navarre. 2016. Intuitive Visual Impressions (Cogs) for Identifying Clusters of Diversity within Potato Species. American Journal of Potato Research 93:350-359.

Jansky, S.H., Charkowski, A.O., Douches, D.S., Gusmini, G., Richael, C., Bethke, P.C., Spooner, D.M., Novy, R.G., De Jong, H., De Jong, W.S., Bamberg, J.B., Thompson, A.L., Bizimungu, B., Holm, D.G, Brown, C.R., Haynes, K.G., Sathuvalli, V.R. et al. 2016. Reinventing potato as a diploid inbred line-based crop. Crop Science 56:1-11.

Chung, Y.S., Palta, J., Bamberg, J., Jansky, S. 2016. Potential molecular markers associated with tuber calcium content in wild potato germplasm. Crop Science 56(2):576-584.

Bruce R. Robinson, Vidyasagar Sathuvalli, John Bamberg, and Aymeric Goyer. 2015. Exploring Folate Diversity in Wild and Primitive Potatoes for Modern Crop Improvement. Genes (Basel). 2015 Dec 8;6(4):1300-14.

Bamberg, J., Moehninsi, R. Navarre, and J. Suriano. 2015. Variation for Tuber Greening in the Diploid Wild Potato Solanum microdontum. American Journal of Potato Research 92:435-443.

Hardigan, M., J Bamberg, C Robin Buell and D Douches. 2015. Taxonomy and genetic differentiation among wild and cultivated germplasm of Solanum sect. Petota. The Plant Genome 8:1:16.

Bamberg, JB, A del Rio, J Coombs and D Douches. 2015. Assessing SNPs versus RAPDs for predicting heterogeneity in wild potato species. American Journal of Potato Research 92:276-283.

Publications of associated ARS staff:

Spooner: https://horticulture.wisc.edu/faculty-profiles/spooner-publications/

Jansky: https://horticulture.wisc.edu/faculty-profiles/jansky_publications/

Land Grant Participating States/Institutions

CO,MI,MN,WI

Non Land Grant Participating States/Institutions

USDA-ARS, USDA-ARS/Idaho

Participation

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA
Bamberg, John	Yes	USDA-ARS	1,2,3,4,5	204	1310	1080	0.10	0.00	0.00	0	0
Douches, David	Yes	Michigan - Michigan State University	1,2,3,4,5	201	1310	1080	0.10	0.00	0.00	0	0
Endelman, Jeffrey		Wisconsin - University of Wisconsin	1,2,3,4,5	201	1310	1080	0.10	0.00	0.00	0.1	201
Holm, David G	Yes	Colorado - Colorado State University	1,2,3,4,5	204 204	1310 1310	1080 1081	0.10	0.00	0.00	0	0
Novy, Richard G		USDA-ARS/Idaho	1,2,3,4,5	0	0	0	0.10	0.00	0.00	0	0
Shannon, Laura	Yes	Minnesota - University of Minnesota	1,2,3,4,5	202 201	1310 1310	1081 1080	0.10	0.00	0.00	0	0

Combined Participation

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
204-1310-1080	0.1	0	0
204-1310-1080	0.05	0	0
204-1310-1081	0.05	0	0
201-1310-1080	0.1	0	0
201-1310-1080	0.05	0	0
202-1310-1081	0.05	0	0
0-0-0	0.1	0	0
201-1310-1080	0.1	0	0
Grand Total:	**0.60**	**0.00**	**0.00**

Program/KA	Total FTE
0	0
0	0
0	0
0	0
0	0
201	0.03
Grand FTE Total:	**0.1**

Budgets

MRF Funding 2020

Description	Dollars	FTE
Salaries	116000.00	1.30
Fringe Benefits	0.00	0.00
Wages	27000.00	0.80
Travel	2000.00	0.00
Supplies	5000.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	0.00	0.00
Totals	**150000**	**2.1**

Comments

NOTE: Budget Tables and associated information are formatted in Attachments section file APPENDICES. Salary line includes 35% fringe. Wages line includes fringe. Supplies line includes maintenance Budgets proposed for subsequent years are the same If level funding of $150K/y does not continue for the rest of the project term, the reduction should be compensated by a reapportionment of SAES contributions or other options proposed in the Midterm review, as negotiated by the project leadership AAs, NPGCC, and RC.

MRF Funding 2021

Description	Dollars	FTE
Salaries	116000.00	1.30
Fringe Benefits	0.00	0.00
Wages	27000.00	0.80
Travel	2000.00	0.00
Supplies	5000.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	0.00	0.00
Totals	**150000**	**2.1**

Comments

Same as first year

MRF Funding 2022

Description	Dollars	FTE
Salaries	116000.00	1.30
Fringe Benefits	0.00	0.00
Wages	27000.00	0.80
Travel	2000.00	0.00
Supplies	5000.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	0.00	0.00
Totals	**150000**	**2.1**

Comments

Same as first year.

MRF Funding 2023

Description	Dollars	FTE
Salaries	116000.00	1.30
Fringe Benefits	0.00	0.00
Wages	27000.00	0.80
Travel	2000.00	0.00
Supplies	5000.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	0.00	0.00
Totals	**150000**	**2.1**

Comments

Same as first year.

MRF Funding 2024

Description	Dollars	FTE
Salaries	116000.00	1.30
Fringe Benefits	0.00	0.00
Wages	27000.00	0.80
Travel	2000.00	0.00
Supplies	5000.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	0.00	0.00
Totals	**150000**	**2.1**

Comments

Same as first year.