

Potato Breeding and Selection for Colorado

RESEARCH PROPOSAL FOR 2015

Submitted to:

Colorado Potato Administrative Committee (Area II) - Research Committee

Title:

Potato Breeding and Selection for Colorado

Funding Source: CPAC, Area II

Project Leaders:

David G. Holm and Caroline Gray, Department of Horticulture and Landscape Architecture, Colorado State University, San Luis Valley Research Center

Collaborators:

- Andrew J. Houser - Disease Screening and Evaluation
- Samuel Y. C. Essah - Cultivar Specific Production Management
- Sastry S. Jayanty - Cultivar Specific Postharvest Management and Physiology
- Adam Heuberger - Nutritional Characteristics and Health Attributes
- Jorge M. Vivanco and Gary E. Gross - Nematode Resistance
- Kent P. Sather - Potato Certification Service
- Colorado Potato Growers
- Other cooperating research/extension programs - several cooperators throughout the United States and Canada provide breeding material and opportunities to screen our germplasm under various growing conditions and disease pressures.

Nature, Scope, and Objectives of the Proposed Research:

Potato cultivar development is a four-step process, encompassing first, the generation of segregating populations and evaluation for visual agronomic traits. Second, superior progenies are identified and these selections undergo additional evaluation for economically important characteristics. Third, a profile of cultivar specific management criteria - production and postharvest - are developed, which a grower, shipper, processor, and/or marketer may fine tune for his/her operation. Finally, the new cultivar must be introduced to the intended market. These steps provide a base for a successful cultivar release. Without all components, fruition is difficult to attain.

The major objectives of the Colorado Potato Breeding and Selection Program are: (1) to develop new potato cultivars with increased yield, improved quality, improved nutritional and health characteristics, resistance to diseases and pests, and tolerance to environmental stresses; (2) to collaborate with growers, shippers, processors, and research/extension personnel to assess the production, adaptability, marketability, and other characteristics of advanced selections from the Colorado program; (3) to provide

a basic seed source of selections to growers for seed increase and commercial testing; (4) to evaluate promising selections for possible export (interstate and international).

The primary emphasis is placed on the development of russet cultivars. The balance of the breeding effort is devoted to developing red, specialty, and chipping cultivars. This broad approach is important because it recognizes the diverse markets accessed by potato growers throughout Colorado.

Besides the major objectives outlined previously, specific breeding emphasis is being placed on identifying germplasm and developing cultivars that have: (1) early vine maturity and early tuber bulking; (2) immunity to PVY; resistance to (3) late blight (foliar and tuber); (4) storage rots [dry rot (*Fusarium* and early blight) and bacterial soft rot]; (5) pink rot; (6) nematodes; (7) powdery scab (mop top virus); (8) corky ringspot, and (9) that have improved nutritional quality, health attributes, and other "consumer" characteristics such as improved red skin color retention and improved shelf life.

Enhancement of the Competitiveness of Colorado Potato Growers:

Many challenges and opportunities are confronting the Colorado potato industry. These challenges/opportunities include new disease pressures, food safety, water quality/supply, current market constraints, new market development (processing, exporting, etc.), changing consumer expectations, and increasing costs with highly variable potato prices. To help meet these challenges, continued emphasis needs to be placed on developing new potato cultivars with economically important characteristics. Also emphasis will be placed on developing sustainable cultivars by selecting for "low input" cultivars, primarily for reduced nitrogen and fungicide inputs and with improved postharvest qualities. Cultivars with these characteristics will help assure that the potato industry in Colorado remains productive and in a competitive position.

Methods:

Table 1 presents a description of the steps involved in developing new potato cultivars. It takes 14+ years to develop a new potato cultivar. Year 1 and 2 are the potato breeding phase of the development process. Parents are selected and crossed to produce true potato seed. Seedling tubers are then produced from the true seed in year 2. Subsequent years (3+) represent the selection phase of the development process. Each year represents another cycle of field selection. As each cycle is completed, fewer and fewer clones remain and the amount of seed per selection is increased. Clones remaining after eight cycles of field selection are released to growers for evaluations prior to official release as a named cultivar.

Facilities, Equipment, Personnel Support:

Facilities/Equipment. The Colorado Potato Breeding and Selection Program is based at the San Luis Valley Research Center. Current facilities and equipment usage are consistent with previous years' needs by this program. A goal still remains to acquire improved grading equipment to facilitate more detailed size profiling of selections under evaluation.

Support Personnel. The partial financial support of a Research Associate by the SLV potato industry for the Colorado Potato Breeding and Selection Program has been very valuable. We also rely on the current SLV Research Center staff to prepare fields for planting and to assist in other activities including seed

preparation, planting, and harvest activities. The collective support activities of Stan Price, Ron Price, Sharon Yust, and Michelle Leckler are greatly appreciated.

Outreach Plan for Reporting Information to Growers and Other Stakeholders:

The Colorado Potato Breeding and Selection Program provides many outreach activities. Included are:

- Field Days - all growers invited
- Annual Open House - all growers invited
- Annual Advanced Selection Evaluation Meeting - all growers invited
- Presentations in various venues including the Southern Rocky Mountain Agricultural Conference and professional meetings
- When requested, articles for SpudItems
- Advanced selections are provided to growers to evaluate for potential release as named cultivars. Our goal is to visit participating growers during late summer and at harvest.
- Tours for individuals and groups
- Website - the website focuses on the various programs located at the SLV Research Center, including potato breeding and selection, postharvest physiology, field physiology, potato pathology, and potato certification. The overall URL for the website is <http://potatoes.colostate.edu>. To go to the potato breeding program section of the website the URL is <http://potatoes.colostate.edu/potato-breeding/>.

Potential for Leverage of Outside Funding:

Ongoing support by the potato industry is fundamental to seeking external funding for potato breeding from NIFA (National Institute of Food and Agriculture) and other potential sources. It illustrates valuable industry partnerships and support. Also, these funds are vital to maintaining collaborative relationships with other research projects supporting the overall potato research efforts in Colorado.

Project Timeline and Expected Short Term and Longer Term Outcomes:

This project is ongoing. Potato cultivar development is a process encompassing a minimum time-period of 12 to 14+ years from hybridization to release of a new cultivar. Based on this timeline, advanced selections from crosses made in 2014 will be available for grower evaluation in 2024. This illustrates the long term nature of potato breeding programs. It also underscores the impact of funding and the significance of other research management decisions on meeting the needs of the Colorado potato industry. For example the characteristics we incorporate into current crosses today will determine what traits future cultivars will possess.

Because the timeline for cultivar development is lengthy, improved methods to speed up the breeding and selection process are continually evaluated. This emphasizes the importance of collaborative efforts with appropriate faculty and staff as we move more into the area of marker assisted selection.

Outcomes for this project are primarily associated with the development of new potato cultivars.

Collaborative Studies:

The following collaborative studies were conducted in 2014. These programs have their own funding and funding is not requested in our budget to support these efforts.

- Several advanced selections were evaluated for disease symptom expression trials in Colorado. These trials were conducted in cooperation with Andrew Houser, Kent Sather, and Rick Haslar (retired). Disease evaluations included bacterial ring rot, PVY, and powdery scab.
- Several advanced selections were distributed to state/USDA-ARS collaborators in Idaho, Michigan, Oregon, Texas, Washington, and Wisconsin for additional disease evaluations. These selections were screened for one or more of the following diseases: late blight, early blight, scab (common and powdery), PVY, *Verticillium* wilt, and zebra chip. In addition, selections were provided to the National Trials for late blight and scab (powdery and common) screening trials.
- Several selections were entered in the National Fry Processing Trials conducted in Washington, Idaho, Maine, and North Dakota. A focus of these trials is to identify selections with low acrylamide potential. Several chippers were entered in the National Chip Processing Trials. These trials were planted in 9 locations in northern and southern areas.
- Germplasm is continually being acquired with late blight resistance, virus resistance (PXY, PVY, corky ringspot and leafroll), and nematode resistance from various sources. Primary sources of new germplasm are the USDA-ARS in Aberdeen, Idaho; Prosser, Washington; Madison, Wisconsin; and Oregon State University in addition to resistant selections identified in our program. These materials are being selectively introgressed into the breeding program.
- Health attributes and nutritional characteristics of advanced selections were evaluated by Sastry Jayanty and Henry Thompson.
- Advanced selections were evaluated in cultural management trials in collaboration with Samuel Essah.
- Efforts continue to find outside funding to support nematode resistance studies with Jorge M. Vivanco and graduate students.

Graduate Students

Katie Larson. *Color, Carotenoid Content and Sensory Perceptions in Potato Germplasm from the Colorado Potato Breeding and Selection Program.* Co-advised by David Holm and Sastry Jayanty. Katie completed her thesis in 2014.

Sara Kammlade. *The Influence of Agromanagement on Soil Health and Potato Mineral Nutrients.* Co-advised by David Holm and Samuel Essah. Sara should complete her thesis early in 2015.

Previous studies have observed differences in the mineral nutrient concentrations of food crops when grown in conventional versus organic systems. However, they have not accounted for inherent dissimilarities in the agroecosystems as a result of differing agromanagement, which may explain how and why such differences are observed. Agromanagement (rotation, fertilizer, pesticide inputs etc.) shapes soil health – the biological, chemical, and physical properties of soil. Soil organisms – bacteria, fungi, protozoa, and nematodes – are essential in regulating biogeochemical cycling and are therefore critical in crop mineral nutrient acquisition. By studying a spectrum of management practices from a conventional “feed the plant” paradigm to a biological “feed the soil” paradigm we can see how these management systems alter soil health and how, in turn, this influences potato mineral nutrients.

The objectives of this research are to:

1. Characterize how a spectrum of agromanagement practices, alter soil health;
2. Determine if and what certain soil health metrics correspond to higher potato mineral nutrients;
3. Determine the heritability of potato mineral nutrient uptake and to determine if high mineral nutrient concentration can be selectively bred for; and
4. Determine the stability of potato mineral nutrient uptake to identify clones that exhibit a stable response across many agroecosystems.

Raven Bough. *Screening Potato Germplasm for Flavor Utilizing HS-SPME/GC-MS and Sensory Panel Analyses.* Co-advised by David Holm and Sastry Jayanty. Raven's thesis completion date has not been determined.

The development of potato cultivars with improved flavor in the San Luis Valley has the potential to expand the region's fresh potato market by focusing on consumer appeal. Through analysis of existing cultivars, the objective of this project is to establish a flavor rating methodology for potato selections based on correlation of HS-SPME/GC-MS quantification of major flavor compounds and sensory panel tests. Flavor ratings will guide germplasm screening in the breeding process, which will enable the development of new cultivars with improved flavor.

Objectives for 2015: (Note - some of objectives listed are collaborative projects and thus will be funded through other sources and are presented here for information only).

1. The Colorado Potato Breeding and Selection Program will be continued. This aspect of the program is primarily oriented to developing new potato cultivars. Emphasis will continue to be placed on developing russet cultivars that have early vine maturity and early tuber bulking.

Advanced clones will be tested in yield trials, Southwestern Regional Trials, Western Regional Trials, out-of-state trials, and by growers.

2. Adjunct breeding initiatives have been started over the last few years and will continue. These initiatives are focused on increasing disease resistance and the nutritional and health attributes of potatoes in collaboration with other CSU faculty.
 - a. Disease resistance breeding has focused on introgressing parental material with identified resistance to late blight, immunity to PVY, tuber resistance to dry rot (*Fusarium* and early blight), and bacterial soft rot. Additional emphasis is being placed on identifying and incorporating germplasm demonstrating resistance/immunity to pink rot, powdery scab, corky ringspot, and nematodes. These studies are in collaboration with Andrew Houser.
 - b. Parental material with improved nutritional and health characteristics will be incorporated in the breeding and selection program. We currently are increasing our emphasis on flavor and the identification of novel material that may be useful to incorporate into our breeding program. This has been facilitated by the CDA Specialty Crop Block Grant "Screening of Potato Germplasm for Flavor as a Potato Breeding Selection Tool". As part of this project new efforts will be directed to sensory evaluations of advanced selections both via taste panels and alternative screening techniques. The above project is in collaboration with Sastry Jayanty and a graduate student.

3. Clones in the 7th cycle of field selection will be evaluated in cultural management trials and for postharvest disease reaction. Disease evaluations will be conducted primarily on bacterial soft rot, and dry rot (*Fusarium* and early blight). These studies will be conducted in cooperation with Andrew Houser and Samuel Essah.
4. Collaborative efforts will continue to focus on an “accelerated” breeding approach for high priority characteristics. This would employ greenhouse and field evaluations, where appropriate, to characterize breeding material earlier in the selection program. Primary focus will include PVY, powdery scab, corky ringspot, and pink rot. Studies will be conducted with other faculty and staff to incorporate MAS where appropriate.
5. Continue the use of on-farm trials to: (1) assist in the development of management guidelines; (2) detect unforeseen problems; (3) determine predictability of performance; and (4) screen for disease reaction [foliar and tuber (pink rot and powdery scab)]. This will be a collaborative effort with Andrew Houser and Samuel Essah. Please refer to the research reports of Andrew Houser and Samuel Essah for 2014 results.
6. Evaluate preliminary, intermediate, and advanced selections from the breeding project, Southwestern Regional Trials, and Western Regional Trials for: blackspot susceptibility, storage weight loss, dormancy, enzymatic browning, specific gravity, chip color, french fry color, and french fry texture.
7. Collaborative efforts will be undertaken with Samuel Essah, Troy Bauder, and Allan Andales to evaluate advanced selections for drought tolerance/water-use efficiency.

2015 Proposed Budget

(2014 - Proposed \$64,000, Funded \$62,000; 2013 - Proposed \$64,000, Funded \$62,500)

Budget Item	Amount	Notes
Research Associate	35,500	Salary plus fringe benefits (partial support)
Temporary Labor	16,250	Hourly support personnel
Supplies	6,900	Miscellaneous greenhouse and field supplies
Travel	700	Travel within Colorado
Equipment & Maintenance	2,600	Greenhouse and assistance to SLVRC
Chemicals	3,050	Greenhouse and some field chemicals
Total Budget	\$65,000	

Table 1. Generalized potato breeding and selection scheme used at the SLV Research Center.

Year	Comments
1	Select parents for crossing and true seed production in the greenhouse.
2	Produce seedling tubers from true seed in the greenhouse.
3	70,000-80,000 seedling tubers planted in the field as single hills. Several thousand tubers are obtained from other breeding programs. Initial selection of this material takes place at harvest. First cycle of field selection.
4	Twelve-hills of each single-hill selection are planted. Second cycle of field selection.
5	Preliminary Selections Tier 1 (PT1). Third cycle of field selection (48 plant tuber-unit seed increase). Initial evaluations for chipping qualities (chip color after various storage regimes and specific gravity) are conducted this year and subsequently.
6	Preliminary Selections Tier 2 (PT2). Fourth cycle of field selection (96 plant tuber-unit seed increase). Initial evaluations to characterize selections for blackspot bruise potential, storage weight loss, dormancy, and enzymatic browning. Initial evaluations for french fry potential (french fry color and specific gravity) are conducted this year and subsequently. Evaluations for chipping qualities are continued.
7	Intermediate Selections. Fifth cycle of field selection. Initial data collected on yield, grade, and growth characteristics. Plant a 144 plant tuber-unit seed increase and a 2 rep x 25 plants intermediate yield trial (IYT).
8-9, 14+	<p>Advanced Selections: Includes selections that have advanced from the IYT. Additionally selections are included that have graduated from the Southwest Regional and Western Regional Trials. The advanced yield trials for reds, specialty types, and chippers are planted with entries in the Western Regional Red, Specialty and Chip Trials. Selections are in the 6th-7th and 12+ cycles of field selection. All advanced yield trials (AYT) have 4 reps x 25 plants. Sixth- and seventh- year field selections respectively have a 400/1,600 plant tuber-unit seed increase.</p> <p>Selections in the sixth cycle of selection are indexed for viruses and cleanup/micropropagation is initiated. Testing for ring rot and PLRV reaction is also initiated at this stage and continues as needed. Selections in the 7th cycle of field selection are entered into cultural management trials and postharvest disease reaction (dry rot and soft rot) evaluations.</p>
10	All 8th year selections have a 1/2 acre tuber-unit seed increase planted. These selections are entered in the Southwestern Regional Trials (4 locations - CO, TX, CA). Cultural management trials and postharvest disease reaction evaluations continue as needed.
11-13	All 9 th year or older selections generally have a 1 acre or greater seed increase. These selections are entered in the Western Regional Trials (4 trials): main (russets and long whites), red, specialty, and chip. The Western Coordinating Committee (WERA027) directs these trials at 10+ locations in the Western United States each year. Cultural management trials and postharvest disease reaction evaluations continue as needed.
11+	Grower/industry evaluations. The Colorado Potato Breeding and Selection Project relies on the cooperation of several growers, shippers, and processors to evaluate advanced selections for adaptability and marketability.
14+	Release as a named cultivar.

