

Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2012 AND RESEARCH PROPOSAL FOR 2013

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:

- Robert D. Davidson and Andrew J. Houser - Disease Screening and Evaluation
- Samuel Y. C. Essah - Cultivar Specific Production Management
- Sastry S. Jayanty - Cultivar Specific Postharvest Management and Physiology
- Lavanya Reddivari and Henry J. Thompson - Nutritional Characteristics and Health Attributes
- Jorge M. Vivanco and Dayakar Badri - Nematode and Pink Rot Resistance
- Kent P. Sather and Richard W. Haslar - Potato Certification Service
- Jairam Vanamala - Bioactive Compounds for Health Laboratory
- 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; (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. Continued 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. However **the 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 Deanna Brown are greatly appreciated. **There is a need of one additional full-time field support person to facilitate the overall activities at the SLV Research Center.**

Outreach Plan for Reporting Information to Growers and Other Stakeholders:

The Colorado Potato Breeding and Selection Program provides for 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. We try to visit participating growers during late summer and at harvest.
- Tours for individuals and groups
- Website - currently we are working on a website for the CSU potato program. This website will focus on the various programs located at the SLV Research Center, including potato breeding and selection, postharvest physiology, field physiology, potato pathology, and potato certification. Links will be provided for campus based potato research programs.

Potential for Leverage of Outside Funding:

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

Project Timeline:

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 2013 will be available for grower evaluation in 2023. This illustrates the long term nature of potato breeding programs. It also underscores the importance of collaborative efforts in cultivar development, the impact of inadequate funding, and the significance of other research management decisions. These factors all have impact on the characteristics that future cultivars will possess as we strive to meet the needs of the Colorado potato industry.

Because the timeline for cultivar development is lengthy, improved methods to speed up the breeding and selection process are continually evaluated. Technologies such as marker assisted selection will be evaluated to facilitate accelerated (focused) breeding for high priority characteristics.

Significant Accomplishments for 2012:

The following is a brief summary of research conducted in 2012.

The Colorado Potato Breeding and Selection Program intercrossed 98 parental clones in 2012 in two separate crossing blocks. The emphasis of the first crossing block was russet and fingerling cultivar development. The second crossing block emphasized russet and chipper cultivar development. Seed from 439 combinations was obtained.

Approximately 61,089 first-size seedling tubers representing 215 families were produced from 2011 greenhouse crosses for initial field selection in 2013. Second through fourth size seedling tubers will be distributed to Idaho (USDA-ARS), Maine, North Dakota, Oregon, Texas, Wisconsin, and Alberta, Canada (Agriculture Canada).

Colorado grew 85,285 first-year seedlings representing 417 families in 2012, with 746 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the USDA-ARS (Aberdeen, Idaho), Agriculture Canada, Texas A&M University, and North Dakota State University. Another 1,033 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 244 were saved for further increase and evaluation. Seventy-five advanced selections were saved and will be increased in 2013 pending further evaluation. Another 288 selections and cultivars were maintained for germplasm development, breeding, and other experimental purposes including seed increase/maintenance.

Field trials conducted in 2012 included: Preliminary Trial, Intermediate Yield Trial, Intermediate Specialty Yield Trial, Advanced Yield Trial, Advanced Fingerling Trial, Southwestern Regional Russet Trial, Southwestern Regional Red Trial, Southwestern Regional Chip Trial, Southwestern Specialty Trial, Western Regional Russet/Processing Trial, Western Regional Red Trial, Western Regional Specialty Trial, Western Regional Chipping Trial, and the San Luis Valley Chipping Trial. All trials are grown under "low input" conditions, primarily for reduced nitrogen and fungicide.

A total of 216 samples are in the process of being evaluated for two or more of the following postharvest characteristics: blackspot susceptibility, storage weight loss, dormancy, enzymatic browning, specific gravity, french fry color, french fry texture, and chip color.

Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by Colorado producers in 2012, included 12 russets (CO04211-4RU, CO04220-7RU, CO04233-1RU, AC00395-2RU, CO03187-1RU, CO03202-1RU, CO03276-4RU, CO03276-5RU, AC99375-1RU, CO99053-3RU, CO99053-4RU, and CO99100-1RU), 4 reds (CO04159-1R, CO00291-5R, CO99076-6R, and CO99256-2R), 11 chippers (AC00206-2W, AC03452-2W, AC01151-5W, AC03433-1W, CO02024-9W, CO02033-1W, CO02321-4W, CO03243-3W, CO00188-4W, CO00197-3W, and CO00270-7W), and 22 specialties (AC03534-2R/Y, CO04029-5W/Y, CO04067-8R/Y, CO04099-3W/Y, CO04099-4W/Y, CO04188-4R/Y, CO04056-3P/PW, CO04063-4R/R, CO03134-4RF/RW, CO04021-2R/Y, CO04013-1W/Y, CO97226-2R/R, CO97232-2R/Y, CO97222-1R/R, CO97227-2P/PW, AC99329-7PW/Y, AC99330-1P/Y, CO99045-1W/Y, ATC00293-1W/Y, CO00405-1RF, CO00412-5W/Y, and CO00415-1RF).

Several selections are being considered for exclusive release. Included are: CO95051-7W, CO96052-1RU, AC97521-1R/Y, CO97215-2P/P, CO99053-4RU, CO98012-5R, CO97233-3R/Y,

CO97232-1R/Y, CO00405-1RF, TC02072-3P/P, CO00277-2R, CO00291-5R, CO97227-2P/PW, CO99045-1W/Y, CO99338-3RU/Y, AC99375-1RU, ATC00293-1W/Y, CO00412-5W/Y, and CO00415-1RF.

Selections to be named are AC99329-7PW/Y (Masquerade), CO99053-3RU (Crestone Russet), CO99100-1RU (name to be determined).

An MS student, Katie Larson, has been working with our yellow-fleshed material for the last two years. She has collected data on flesh color and carotenoid content (qualitative and quantitative analysis). She has also conducted an analysis of sensory/flavor characteristics of a subset of selections. More detailed results from her project will be presented next year.

Table 2 compares the more advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Collaborative Studies:

The following collaborative studies were conducted in 2012. These programs have their own funding for these projects and funding is not requested in our budget to support these efforts.

- Several advanced selections were evaluated for disease symptom expression screening trials in Colorado. These trials were conducted in cooperation with Rob Davidson, Andrew Houser, Kent Sather, and Rick Haslar. Disease evaluations included bacterial ring rot, potato leafroll virus, 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 selections were evaluated by Sastry Jayanty, Henry Thompson, Jairam Vanamala, and Lavanya Reddivari.
- 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 Dayakar Badri. Initial studies aimed at pink rot resistance were initiated in 2010.
- Marketing and associated branding studies were initiated with Rob Davidson, Sastry Jayanty, Samuel Essah, and Jennifer Bond with funding provided by a Specialty Crop Block Grant provided by the Colorado Department of Agriculture.

Objectives for 2012: (Note - some of objectives listed are funded through other sources and are presented here for information only).

1. The potato breeding and selection program will be continued. This aspect of the program is primarily oriented to developing new potato cultivars. *Note:* With the ongoing virus situation with Russet Norkotah, continued emphasis will be placed on developing 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), 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 Rob Davidson and 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 taste/texture and the identification of novel material that may be useful to incorporate into our breeding program. Concurrently new efforts will be directed to sensory evaluations of advanced selections both via taste panels and alternative screening techniques. Screening for resistant starch will also be emphasized. Additionally we will begin new efforts to screen for mineral nutrients and study Vitamin C retention. This work is in collaboration with Sastry Jayanty, Samuel Essah, and Lavanya Reddivari.
 - c. Continue efforts to develop opportunities to evaluate advanced selections and cultivars for various sensory attributes.
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, dry rot (*Fusarium* and early blight) and corky ringspot. These studies will be conducted in cooperation with Rob Davidson 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.

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 Rob Davidson and Samuel Essah. Please refer to the research reports of Rob Davidson and Samuel Essah for 2012 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. Another graduate student, Sara Kammlade, will initiate a study this year looking at nutrient density of potatoes when grown under organic and conventional production systems. Additionally we will study starch content and quality. This will be a collaborative project with Samuel Essah and Sastry Jayanty.

Budget Request for 2013 (2011 and 2012 - \$63,000):

Request	\$64,000	
Research Associate	35,500	Salary plus fringe benefits (partial support)
Temporary Labor	15,950	Hourly support personnel
Supplies	6,600	Miscellaneous greenhouse and field supplies
Travel	700	Travel within Colorado
Equipment & Maintenance	2,200	Greenhouse and assistance to SLVRC
Chemicals	3,050	Greenhouse and some field chemicals

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+	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. 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.
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.

Table 2. Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Clone	Usage ¹	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity ²	Specific Gravity	% External Defects ³	% Hollow Heart ⁴
Russets								
CO99053-3RU	Dual	7	501	89	3.3	1.089	3.6	0.7
CO99100-1RU	Dual	7	358	85	1.4	1.084	3.9	0.2
AC00395-2RU	Dual	5	494	86	3.9	1.103	1.2	0.6
CO03187-1RU	Dual	4	367	77	1.3	1.087	0.7	0.0
CO03276-5RU	Dual	4	429	67	2.1	1.087	0.4	0.0
Canela Russet	FM	23	369	90	3.1	1.098	1.1	0.1
Centennial Russet	FM	35	294	77	3.0	1.080	0.8	0.3
Mesa Russet	Dual	10	419	86	2.9	1.082	1.8	2.5
Rio Grande Russet	FM	22	533	80	3.0	1.087	2.8	0.4
Russet Norkotah	FM	90	380	84	1.8	1.079	2.2	0.4
Russet Nugget	Dual	64	441	81	3.8	1.093	1.5	0.2
Reds								
CO99076-6R	FM	7	403	78	1.6	1.087	2.2	0.0
CO99256-2R	FM	7	522	69	2.9	1.089	0.4	0.1
Colorado Rose	FM	14	517	85	2.7	1.082	2.7	0.3
Rio Colorado	FM	11	405	56	1.7	1.087	0.9	0.0
Sangre-S10	FM	33	536	88	3.3	1.077	2.2	1.5
Specialties								
CO97226-2R/R	Spec	7	364	34	2.3	1.080	0.2	0.0
CO97232-2R/Y	Spec	7	440	84	2.6	1.071	0.8	1.0
CO97222-1R/R	Spec	7	396	58	2.5	1.076	1.5	0.0
AC99329-7PW/Y	Spec	7	522	79	3.1	1.092	1.6	0.4
AC99330-1P/Y	Spec	7	495	58	2.9	1.082	0.0	0.2
CO01399-10P/Y	Spec	6	543	75	3.5	1.080	0.8	0.1
CO04021-2R/Y	Spec	4	551	88	3.3	1.086	1.7	0.2
Mountain Rose	Spec	8	383	68	2.2	1.081	1.1	0.0
Purple Majesty	Spec	21	482	55	2.2	1.086	0.6	1.0
Yukon Gold	Spec	35	407	89	1.9	1.086	1.6	0.5

Table continued on next page

Table 2 (cont'd). Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Clone	Usage ¹	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity ²	Specific Gravity	% External Defects ³	% Hollow Heart ⁴
Chippers								
CO00188-4W	Chip	7	420	77	2.5	1.092	2.2	0.1
CO00197-3W	Chip	7	462	73	2.2	1.087	0.9	0.7
CO00270-7W	Chip	7	400	84	2.6	1.087	1.7	0.0
AC01151-5W	Chip	5	478	80	3.0	1.091	2.4	0.1
CO02024-9W	Chip	5	420	80	3.0	1.089	1.7	0.2
CO02033-1W	Chip	5	434	85	2.7	1.099	0.8	1.5
CO02321-4W	Chip	5	437	82	2.8	1.102	3.2	0.0
AC03433-1W	Chip	4	432	82	3.4	1.089	6.0	0.0
CO03243-3W	Chip	4	470	87	3.1	1.089	1.8	0.4
Atlantic	Chip	43	460	87	3.2	1.098	2.5	4.8
Chipeta	Chip	40	538	84	3.3	1.090	5.2	0.6

¹FM=fresh market; Dual= fresh market and processing potential; SPEC=specialty.

²Vine maturity: 1=very early; 2=early; 3=medium; 4=late; 5=very late.

³Includes defects such as second growth, growth crack, misshapen, and green.

⁴Based on tubers greater than 10 ounces.

*Clones discontinued from further grower evaluations by year:

2011: CO95051-7W, CO96052-1RU, AC97521-1R/Y, CO97215-2P/P

2012: CO99053-4RU, CO98012-5R, CO97233-3R/Y, CO97232-1R/Y, CO00405-1RF, TC02072-3P/P

2013: CO00277-2R, CO00291-5R, CO97227-2P/PW, CO99045-1W/Y, CO99338-3RU/Y, AC99375-1RU, ATC00293-1W/Y, CO00412-5W/Y, CO00415-1RF

Any clone which has been discontinued may be available for exclusive release through CSU. Please contact either David Holm or Rob Davidson for further information.