Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2007
AND RESEARCH PROPOSAL FOR 2008

Submitted to:

Colorado Potato Administrative Committee (Area II) - Research Committee

Title:

Potato Breeding and Selection for Colorado

Project Leaders:

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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
Cecil Stushnoff and Henry J. Thompson - Nutritional Characteristics and Health Attributes
Jorge M. Vivanco - Molecular Studies
Kent P. Sather and Richard W. Haslar - Potato Certification Service
Jennifer Bond - Marketing

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 not available in Colorado.

Project Justification and Scope:

Many challenges and opportunities are confronting the Colorado potato industry. These challenges/opportunities include 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.

Potato cultivar development is a four-step process, encompassing first, the generation of segregating populations and evaluation for visual agronomic traits. Second, superior progeny 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 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.

In addition to 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) immune to PVY; resistant 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; and (8) that have improved nutritional quality, health attributes, and other "consumer" characteristics such as improved red skin color retention and improved shelf life.

Continued emphasis will be placed on breeding/selecting for "low input" cultivars, primarily for reduced nitrogen and fungicide input, for improved postharvest and processing qualities such as lengthened dormancy and ability to process after cold storage. Cultivars with these characteristics will help assure that the potato industry in Colorado will remain 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. Years 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 needs are consistent with previous years' usage by this program.

Previously, the primary limiting facilities/equipment were associated with grading and postharvest evaluations. A goal for sometime has been to acquire improved grading equipment to enhance our data collection process. The addition of the new building at the SLV Research Center in 2005 greatly improved our efforts to conduct postharvest tuber quality evaluations.

Support Personnel. The 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, assist in seed preparation, planting, and harvest activities. The collective support activities of Stan Price, Ron Price, and Sharon Yust are greatly appreciated.

Potential for Leverage of Outside Funding:

Ongoing support by the potato industry is fundamental to maintaining external funding received for Potato Cultivar Development from CSREES 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 time line, advanced selections from crosses made in 2007 will be available for grower evaluation in 2018. 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 that other research management decisions have on the characteristics that future cultivars will possess as we strive to meet the needs of the Colorado potato industry.

Significant Accomplishments for 2007:

The following is a brief summary of research conducted in 2007.

The Colorado Potato Breeding and Selection Program intercrossed ninety-three parental clones in 2007 in two separate crossing blocks. The emphasis of the first crossing block was russet, red, and specialty cultivar development. The second emphasized russet and red cultivar development, PVY immunity, and nematode resistance. Seed from 383 combinations was obtained.

Approximately 46,227 seedling tubers representing 249 families were produced from 2003, 2005, and 2006 crosses, for initial field selection in 2008. These seedlings represent crosses segregating primarily for russet, reds, specialty types, and disease resistance/immunity (late blight, PLRV, and PVY). Second through fourth size seedling tubers will be distributed to Idaho (USDA-ARS), Minnesota, North Dakota, Texas, Wisconsin, and Alberta, Canada (Agriculture Canada).

Colorado grew 80,101 first-year seedlings in 2007, with 643 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the USDA-ARS, Agriculture Canada, North Dakota State University, and Texas A&M University. Another 893 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 229 were saved for further observation. Forty-three advanced selections were saved and will be increased in 2008. Another 262 selections and cultivars were maintained for germplasm development, breeding, other experimental purposes, or seed increases for other programs.

Field trials conducted in 2008 included: Preliminary Trial, Intermediate Yield Trial, Advanced Yield Trial, Southwestern Regional Trial, Western Regional Russet/Processing Trial, Western Regional Red Trial, Western Regional Specialty Trial, San Luis Valley Chipping Study, and Western Regional

Chipping Trial. All trials are grown under "low input" conditions, primarily for reduced nitrogen and fungicide.

A total of 160 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 producers in 2007, included 8 russets (AC96052-1RU, CO94035-15, CO95172-3RU, CO97087-2RU, CO97138-3RU, CO97138-7RU, CO98067-7RU, and CO98368-2RU), 4 reds (CO98012-5R, CO99076-6R, CO99256-3R, and CO99256-2R), 5 chippers (AC97097-14W, AC99213-8W, CO96141-4W, CO97043-14W, and CO97065-7W), and 13 specialties (AC97521-1R/Y, AC99329-7PW/Y, AC99330-1P/Y, CO97215-2P/P, CO97222-1R/R, CO97226-2R/R, CO97227-2P/PW, CO97232-1R/Y, CO97232-2R/Y, CO97233-3R/Y, CO99045-1W/Y, CO99338-3RU/Y, and VC1009-W/Y).

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

Two cultivars were named in 2007 including Canela Russet (AC92009-4RU) and Rio Colorado (NDC5281-2R). Canela Russet is a fresh market selection with a medium-high total yield and excellent tuber type. It has a low level of external and internal grade defects. Tubers have a long dormancy minimizing the need for sprout inhibition in storage. Rio Colorado is an early maturing red developed for the B sized market. Rio Colorado has excellent tuber color and color retention in storage compared with many popular reds in the marketplace. Tubers have good storability with minimal external and internal grade defects.

The following collaborative studies were conducted in 2007:

- 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. Included were bacterial ring rot (33 entries), potato leafroll virus (19 entries), PVY (20 entries), and powdery scab (17 entries) in Colorado.

- Five 5th year selections were screened for late blight resistance by Oregon State University in 2007. Additionally, all of the Southwestern Regional Trial entries were also evaluated by Oregon State.

- Several advanced selections were distributed to state collaborators in Idaho, Michigan, Oregon, 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) and PVY. In addition, selections were provided to the National Trials for late blight and scab (powdery and common) screening.

- Germplasm is continually being acquired with late blight resistance, virus resistance (PXY, PVY, and leafroll), and nematode resistance from various sources. Primary sources of germplasm are the USDA-ARS in Aberdeen, Idaho; Prosser, Washington; Madison, Wisconsin; and Oregon State University. These materials are being selectively introgressed into the breeding program.

- Advanced selections were evaluated in cultural management trials in collaboration with Samuel Essah.

- A study was continued with Jorge Delgado, USDA-ARS, to examine the mineral element content of several advanced selections. Tubers will be analyzed for macro- and micro-nutrients to determine how this relates to nutrient-use efficiency. This may also have some bearing on human mineral nutrition.

Objectives for 2008: (Note - some of objectives listed are funded through other sources and presented here for information only).

1. The potato breeding and selection program will be continued. This aspect of the program is primarily oriented to develop new potato cultivars. ***Note:*** With the current virus situation with Russet Norkotah, additional 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, and nematodes.

   b. Parental material with improved nutritional and health characteristics will be incorporated in the breeding and selection program.

3. *In vitro* culture studies with breast and colon cancer cells will be used to screen several potato clones for inhibitory effects. This is a collaborative study with Cecil Stushnoff and Henry Thompson.

4. 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 Rob Davidson and Samuel Essah.

5. Collaborative efforts will continue to expand 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, and pink rot.

6. 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 2007 results.

7. 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.

Budget Request for 2008:

Request	$61,500	
Postdoc	35,100	Salary plus fringe benefits
Temporary Labor	15,250	Hourly support personnel
Supplies	6,100	Miscellaneous greenhouse and field supplies
Travel	500	Travel within Colorado
Equipment & Maintenance	2,400	Greenhouse and assistance to SLVRC
Chemicals	2,150	Primarily greenhouse 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 1 (P1). 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 2 (P2). 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 9th 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 (WCC-27) 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 1. Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects- 2007. Advanced selections that may be released for grower evaluation in 2008 are highlighted.

Clone	Usage[1]	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity[2]	Specific Gravity	% External Defects[3]	% Hollow Heart[4]
Russets								
CO94035-15RU	Dual	8	415	85.8	2.9	1.082	2.1	3.0
CO95172-3RU	FM	7	497	81.7	3.2	1.088	1.2	0.6
AC96052-1RU	Dual	6	450	87.9	3.3	1.090	1.0	0.2
CO97087-2RU	Dual	5	425	86.3	3.0	1.096	2.2	0.1
CO98067-7RU	**Dual**	**4**	**457**	**87.5**	**2.4**	**1.077**	**1.0**	**0.0**
CO98368-2RU	**FM**	**4**	**400**	**75.3**	**2.3**	**1.084**	**1.2**	**0.0**
Canela Russet	FM	11	386	89.8	3.1	1.096	1.3	0.1
Centennial Russet	FM	35	294	77.4	3.0	1.080	0.8	0.3
Rio Grande Russet	FM	14	521	83.4	3.1	1.086	3.4	0.7
Russet Norkotah	FM	68	367	84.5	1.8	1.078	2.3	0.4
Russet Nugget	Dual	64	440	81.3	3.8	1.093	1.5	0.2
Reds								
CO98012-5R	**FM**	**4**	**436**	**78.7**	**3.0**	**1.079**	**0.7**	**0.5**
Colorado Rose	FM	13	514	84.1	2.7	1.082	2.9	0.3
Rio Colorado	FM	11	405	55.8	1.7	1.087	0.9	0.0
Sangre-S10	FM	20	536	87.7	3.4	1.075	2.1	2.0
Specialties								
VC1009-1W/Y	Spec	7	595	72.4	3.3	1.085	2.1	1.1
AC97521-1R/Y	Spec	5	572	79.4	2.9	1.089	0.4	1.1
CO97226-2R/R	Spec	5	367	37.6	2.2	1.080	0.2	0.0
CO97232-1R/Y	Spec	5	419	71.1	2.0	1.081	0.7	0.0
CO97232-2R/Y	Spec	5	443	87.0	2.6	1.070	0.8	1.0
CO97233-3R/Y	Spec	5	489	75.1	3.4	1.082	4.5	3.0
CO97215-2P/P	**Spec**	**4**	**435**	**74.1**	**3.1**	**1.088**	**1.9**	**0.6**
CO97222-1R/R	**Spec**	**4**	**379**	**56.9**	**2.4**	**1.076**	**1.9**	**0.0**
CO97227-2P/PW	**Spec**	**4**	**473**	**25.9**	**2.7**	**1.087**	**1.1**	**0.0**

Table 1 continued on next page.

Table 1 (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]
All Blue	Spec	12	518	61.0	3.0	1.085	0.6	0.2
Mountain Rose	Spec	7	382	68.3	2.1	1.081	1.3	0.0
Purple Majesty	Spec	7	485	63.8	2.0	1.083	0.8	1.7
Yukon Gold	Spec	20	404	88.2	1.8	1.085	1.9	0.6
Chippers								
CO95051-7W	Chip	6	418	86.5	3.4	1.098	1.1	0.3
CO96141-4W	Chip	6	416	88.8	2.6	1.087	1.2	0.0
AC97097-14W	Chip	5	442	84.1	3.1	1.095	0.8	2.8
CO97043-14W	Chip	5	422	84.3	3.0	1.089	1.5	0.4
CO97065-7W	Chip	5	419	86.3	2.6	1.098	0.9	0.2
Atlantic	Chip	33	455	86.9	3.2	1.097	2.7	5.3
Chipeta	Chip	31	534	84.2	3.3	1.089	5.4	0.5

[1]FM=fresh market; Dual= fresh market and processing potential; Spec=specialty.

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

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

[4]Based on tubers greater than 10 ounces.