

Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2003 AND RESEARCH PROPOSAL FOR 2004

Submitted to:

SLV Research Center Committee
and the
Colorado Potato Administrative Committee (Area II)

Title:

Potato Breeding and Selection for Colorado

Project Leaders:

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Collaborators:

Disease Screening and Evaluation - Robert D. Davidson and Richard T. Zink
Cultivar Specific Management and Storage Studies - Samuel Y. C. Essah
Nutritional Characteristics and Health Attributes - Cecil Stushnoff
Late Blight and Potato Root Exudates - Jorge M. Vivanco.

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.

Cultivar development is a four-step process, encompassing first, the generation of segregating populations followed by 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, or processor, and/or marketer may fine tune for his/her operation. Finally, market development takes place to determine consumer acceptance and recognition in the market. Each of these integrated steps is critical in the development and commercialization of new cultivars and provides the base for a successful cultivar release.

The major objectives of the Colorado Potato Breeding and Selection Program are: (1) to develop new potato cultivars (russets, reds, chippers, and specialty) with increased yield, improved quality, resistance to diseases and pests, and tolerance to environmental stresses; (2) to provide a basic seed source of selections to growers for seed increase and commercial testing; and (3) to evaluate promising selections for potential seed 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. The development of "low input" cultivars, primarily for reduced nitrogen and fungicide input has always been emphasized. Additional breeding emphasis is placed on identifying germplasm and developing cultivars that are: (1) immune to PVY; (2) resistant to late blight (foliar and tuber); (3) resistant to storage rots [dry rot (*Fusarium* and early blight) and bacterial soft rot]; (4) resistant to powdery scab; and (5) that have improved nutritional quality and other "consumer" characteristics such as improved red skin color retention and improved shelf life. Continued emphasis will be placed on breeding 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 (Table 1). 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.

Currently the main limiting facilities/equipment are associated with grading and postharvest evaluations. A goal for sometime has been to acquire improved grading equipment to enhance our data collection process. Within the scope of the current facility improvement project, it is likely that adequate laboratory and walk-in cooler space may not be available for the next year or longer. These facilities are needed to support postharvest evaluations of tuber quality and culinary (cooking) 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 and assist in seed preparation for planting. Beyond personnel and temporary support funded by the Program, additional support is primarily needed at planting and harvest to operate field equipment. 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:

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 2004 will be available for grower evaluation in 2014. 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 future cultivars will possess as we strive to meet the needs of the Colorado potato industry.

Significant Accomplishments for 2003:

Ninety parental clones were intercrossed in 2003 in two separate crossing blocks. The emphasis of the first crossing block was specialty cultivar development and the second emphasized russets, reds, chippers, and PVY immunity. Seed from 446 combinations was obtained. Approximately 50,000 seedling tubers representing 213 families were produced from 2000, 2001, and 2002 crosses, for initial field selection in 2004. These seedlings represent crosses primarily segregating for russet, reds, chippers, specialty types, and disease resistance/immunity (late blight and PVY). Second through fourth size seedling tubers will be distributed to the USDA-ARS (Idaho), the University of Minnesota, Texas A&M University, the University of Wisconsin, and Agriculture Canada in 2004.

Colorado grew 68,371 first-year seedlings in 2003, with 576 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the USDA-ARS (Idaho), Agriculture Canada, Texas A&M University, and the University of Wisconsin. Another 1,101 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 336 were saved for further observation. Forty-two advanced selections were saved at harvest and will be increased in 2004 pending final evaluations. Another 241 selections and cultivars were maintained for germplasm development, breeding, other experimental purposes, or seed increases for the other programs.

Field trials conducted in 2003 included: Preliminary Trial, Intermediate Yield Trial, Advanced Yield Trial, Southwestern Regional Trial, Western Regional Main Trial, Western Regional Red Trial, Western Regional Specialty Trial, San Luis Valley Chipping Study, and Western Regional Chipping Trial.

Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers in 2003, included 10 russets (AC87084-3RU, AC89536-5RU, AC92009-2RU, AC93026-9RU, CO85026-4RU, CO93001-11RU, CO93016-3RU, CO94035-15RU, CO94084-12RU, and TC1675-1RU), 6 reds (CO86218-2R, CO89097-2R, CO93037-6R, CO94019-1R, NDC5281-2R, and VC1075-1R), 5 chippers (AC87340-2W, AC94296-5W, BC0894-2W, CO95051-7W, and CO95070-7W), and 8 specialty selections (CO94165-3P/P, CO94183-1R/R, VC0967-2R/Y, VC0967-5R/Y, VC1002-3W/Y, VC1009-1W/Y, VC1015-1R/Y, and VC1015-7R/Y).

Advanced selections that were discarded from further evaluation are AC87084-3RU, CO93016-3RU, CO94084-12RU, CO94019-1R, AC87340-2W, AC94296-5W, CO95070-7W, VC0967-5R/Y, VC1015-1R/Y. Based on initial San Luis Valley grower results in 2003 a decision was made to discard CO93037-6R. However, this selection had the highest merit score in the Western Regional Red Trials and will be retained for further regional evaluation.

Selections scheduled for initial release for grower evaluations in 2004 are CO94035-15RU, VC0967-2R/Y, and VC1002-3W/Y. Table 2 summarizes the performance of these selections and others currently undergoing grower evaluation.

Advanced selections undergoing commercialization include AC89536-5RU, and CO89097-2R. Exclusive release or public release for BC0894-2W, CO85026-4RU (Fremont Russet), and CO86218-2R (Durango Red) will be evaluated.

A total of 216 samples were 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. Eighteen advanced selections and named cultivars were screened for greening susceptibility.

The following collaborative studies were conducted:

- 87 selections and named cultivars from 2003 are being screened for antioxidant activity and vitamin C in cooperation with Cecil Stushnoff. Twelve advanced selections and named cultivars are being screened for root exudates for a potential new source of antibiotics in cooperation with Jorge Vivanco.
- Twenty-seven advanced selections were evaluated in cultural management trials in collaboration with Samuel Essah.
- Several advanced selections were evaluated for disease symptom expression in cooperation with Rob Davidson and Rick Zink. Included were: bacterial ring rot (30), potato leafroll virus (18), and powdery scab (9) in Colorado.
- Forty-nine selections were screened for late blight resistance by Oregon State University in 2002. Those with high levels of resistance to foliar infection (about 45%) were reevaluated in 2003. A total of 75 selections from Colorado were screened in 2003. Results are pending at this time.
- Several advanced selections were sent to Michigan, Minnesota, Oregon, and Wisconsin for additional disease evaluations.

Objectives for 2004:

1. The potato breeding and selection program will be continued. This aspect of the program is primarily oriented to developing new potato cultivars.

Advanced clones will be tested, as appropriate 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 have focused on increasing disease resistance and the nutritional and health benefits 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. Recent emphasis has been placed on identifying and incorporating germplasm demonstrating resistance to powdery scab.
- b. Parental material with improved nutritional and health characteristics will be incorporated in the breeding and selection program. Screening of advanced selections for root exudates with potential antibiotic activity will be expanded as warranted.

As information becomes available on advanced selections nearly commercialization, comparative nutrition labels will be developed with the current label and Russet Burbank.

3. Clones in the 7th cycle of field selection will be evaluated in cultural management screening trials located with grower cooperators 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.
4. A collaborative study will be initiated to evaluate the use of 2,4-D to enhance the color of red potatoes in cooperation with Samuel Essah.
5. Collaborative efforts will continue to explore and 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 breeding program. Initial focus will included PVY and powdery scab.
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. Advanced selections will be screened, as appropriate, for tuber greening potential and red skin color retention in storage.

Budget Request for 2004:

Request*	\$58,600	
Research Associate	33,600	Salary plus fringe benefits
Temporary Labor	15,650	Hourly support personnel
Supplies	5,500	Miscellaneous greenhouse and field supplies
Travel	500	Travel within Colorado
Equipment & Maintenance	2,200	Greenhouse and assistance to SLVRC
Chemicals	1,150	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+	<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 (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 2. Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects - 2003. Advanced selections that may be released for grower evaluation in 2004 are highlighted.

Clone	Usage ¹	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity ²	Specific Gravity	% External Defects ³	% Hollow Heart ⁴
<i>Russets</i>								
AC89536-5RU	FM	10	518	81.7	3.1	1.087	3.4	0.5
AC92009-4RU	FM	6	347	89.3	3.1	1.093	1.2	0.0
TC1675-1RU	Dual	6	447	75.6	3.2	1.090	3.9	0.1
AC93026-9RU	FM	5	485	76.9	3.2	1.088	2.8	0.2
CO93001-11RU	Dual	5	423	81.4	2.4	1.079	3.7	0.4
CO94035-15RU	Dual	4	432	85.0	2.9	1.082	2.1	2.9
Centennial Russet	FM	35	294	77.4	3.0	1.080	0.8	0.3
Russet Norkotah	FM	49	372	83.6	1.9	1.077	2.2	0.5
Russet Nugget	Dual	48	423	80.4	3.7	1.092	1.6	0.2
<i>Reds</i>								
CO89097-2R	FM	11	516	83.7	2.9	1.082	3.0	0.3
NDC5281-2R	FM	6	396	48.6	1.9	1.086	0.7	0.0
CO93037-6R	FM	5	592	71.4	3.1	1.082	2.8	0.1
Sangre	FM	25	478	86.1	2.9	1.073	1.6	1.3
<i>Specialty</i>								
CO94165-3P/P	Spec	4	489	63.2	2.3	1.082	1.1	2.0
CO94183-1R/R	Spec	4	407	73.8	2.6	1.080	1.5	0.0
VC0967-2R/Y	Spec	4	452	83.6	2.6	1.074	0.9	0.1
VC1002-3W/Y	Spec	4	472	49.2	2.7	1.090	0.8	0.2
All Blue	Spec	4	532	61.7	2.7	1.080	0.6	0.0
Yukon Gold	Spec	12	404	87.6	1.9	1.084	2.2	0.9

¹ FM=fresh market; Fry=french fry; 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.