

Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2006 AND RESEARCH PROPOSAL FOR 2007

Submitted to:

Colorado Potato Administrative Committee (Area II) - Research Committee

Title:

Potato Breeding and Selection for Colorado

Project Leaders:

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CSU Collaborators:

Disease Screening and Evaluation - Robert D. Davidson and Andrew J. Houser

Cultivar Specific Management - Samuel Y. C. Essah

Postharvest Physiology - Sastry S. Jayanty

Nutritional Characteristics and Health Attributes - Cecil Stushnoff and Henry J. Thompson

Molecular Studies - Jorge M. Vivanco

Potato Certification Service - Kent P. Sather and Richard W. Haslar

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 provide a basic seed source of selections to growers for seed increase and commercial testing; (3) 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; and (4) 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; resistant to (2) late blight (foliar and tuber); (3) storage rots [dry rot (*Fusarium* and early blight) and bacterial soft rot]; (4) pink rot; (5) nematodes; (6) 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. 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.

Funding Note: Significant changes are occurring regarding funding for potato research throughout the US at the federal level. The following is quoted from information recently distributed by the National Potato Council for the "Public Policy Conference" recently held in Washington, D. C.

"Since the Congress determined not to provide for "earmarks" within the Continuing Resolution for Fiscal Year 2007, the National Potato Council urges the various USDA agencies to continue to fund programs critical to potato growers since these earmarks are expected to continue in the FY 2008 bill under new disclosure rules. For example, the \$1.4 million for the CSREES Special Potato Research Grant was eliminated in FY 2007 budget and the funds absorbed into the formula grant programs. An interruption in CSREES funded projects will result in significant disruption or cancellation of valuable breeding research and the loss of varieties resulting from years of previous research. Much of this potato research is conducted jointly using potato industry and university funding."

In FY2006, Colorado received \$138,416 from CSREES for "Potato Breeding and Cultivar Development in the Southwest". Of this amount, Colorado received \$62,426 and \$75,990 was subcontracted to Texas and California per the research proposal submitted by the cooperating states. Preliminary indications are that the Colorado Potato Breeding and Selection Program will receive approximately 45% of the amount that we received last year or \$28,092. Currently we are identifying the potential impact on our program which will most likely be in the areas of the research objectives and personnel unless additional "bridging" funding can be obtained. It is anticipated that CSREES funds may be restored in subsequent fiscal years. The CSREES funds have been a critical source to enhance the overall operations of the breeding program and to initiate adjunct breeding initiatives over the last few years. These initiatives have primarily focused on increasing disease resistance and the nutritional and health attributes of potatoes in collaboration with other CSU faculty.

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 2006 will be available for grower evaluation in 2017. 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 2006:

The following is a brief summary of research conducted in 2006. A complete research progress report for 2006 will be presented at the research reporting meeting on March 7, 2007.

Ninety-three parental clones in 2006 were planted in two separate crossing blocks. The emphasis of the first crossing block was russet cultivar development, PVY immunity, and nematode resistance. The second emphasized russets, reds, specialty, and late blight resistance. Seed from 272 combinations was obtained.

Approximately 55,215 seedling tubers representing 282 families were produced from 2004 and 2005 crosses, for initial field selection in 2007. 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.

Colorado grew 80,019 first-year seedlings in 2006, with 653 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 1,080 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 263 were saved for further observation. Forty-eight advanced selections were saved at harvest and will be increased in 2007 pending final evaluations.

Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers in 2006, included 9 russets (AC96052-1RU, CO94035-15RU, CO95086-8RU, CO95172-3RU, CO97087-2RU, CO97090-4RU, CO97138-3RU, CO97138-7RU, and TC1675-1RU), 1 red (CO98012-5R), 7 chippers (AC97097-14W, ATDC9801-3P, CO95051-7W, CO96141-4W, CO97043-14W, CO97065-7W, and CO98277-4W), and 16 specialty selections (AC97521-1R/Y, ATC98444-1R/Y, ATC98495-1W/Y, ATC98509-1R/Y, CO97215-2P/P, CO97222-1R/R, CO97226-2R/R, CO97227-2P/PW, CO97232-1R/Y, CO97232-2R/Y, CO97233-3R/Y, CO97274-2W/Y, VC0967-2R/Y, VC1002-3W/Y, VC1009-1W/Y, and VC1123-2W/Y) and one long white (CO97137-1W).

Recent releases undergoing commercialization include Rio Grande Russet (AC89536-5RU), Colorado Rose (CO89097-2R), Mountain Rose (CO94183-1R/R), and Purple Majesty (CO94165-3P/P). Exclusive release or public release for BC0894-2W, CO85026-4RU (Fremont Russet), CO86218-2R (Durango Red), CO95086-8RU, TC1675-1, VC0967-2R/Y, VC1002-3W/Y, and VC1123-2W/Y is being evaluated. Two new releases will be finalized in early 2007. They are Canela Russet (AC92009-4RU) and Rio Colorado (NDC5281-2R). Canela Russet is a fresh market selection with excellent tuber type and a long dormancy. Rio Colorado has a bright red skin with a high percentage of B sized tubers.

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

Plant Variety Protection is pending for Keystone Russet, Silverton Russet, Colorado Rose, Rio Grande Russet, Mountain Rose, and Purple Majesty. Applications for Canela Russet and Rio Colorado will be submitted in early 2007.

A total of 202 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.

The following collaborative studies were conducted in 2006:

- 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 (29 entries), potato leafroll virus (24 entries), PVY (25 entries), and powdery scab (19 entries) in Colorado.
- Five 4th year selections were screened for late blight resistance by Oregon State University in 2006. 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, and Cecil Stushnoff to examine the mineral element content and vitamin C content for 105 potato selections and named cultivars grown in Colorado. The study was expanded in 2006 to include selections and cultivars grown in the Southwest Regional Trials in Colorado, Texas, and California (2 sites). 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 2007: (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.

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 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. Initial 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 Samuel Essah's report for 2006 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.
8. Studies in conjunction with Jorge Delgado, USDA-ARS, examining tubers for macro- and micro-nutrients and nutrient-use efficiency will continue.

Budget Request for 2007:

Request	\$60,500	
Postdoc	35,100	Salary plus fringe benefits
Temporary Labor	14,650	Hourly support personnel
Supplies	5,900	Miscellaneous greenhouse and field supplies
Travel	500	Travel within Colorado
Equipment & Maintenance	2,200	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 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 - 2006. Advanced selections that may be released for grower evaluation in 2007 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	6	505	81.3	3.3	1.088	1.3	0.7
AC96052-1RU	Dual	5	458	87.1	3.4	1.088	1.1	0.2
CO97087-2RU	Dual	4	427	86.0	2.9	1.095	2.2	0.2
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	12	525	82.6	3.1	1.086	3.8	0.8
Russet Norkotah	FM	63	368	84.6	1.8	1.078	2.2	0.4
Russet Nugget	Dual	60	440	81.3	3.8	1.093	1.5	0.2
Reds								
Colorado Rose	FM	12	518	83.7	2.8	1.082	3.0	0.3
Rio Colorado	FM	11	405	55.8	1.7	1.087	0.9	0.0
Sangre-S10	FM	18	541	87.5	3.4	1.075	2.3	2.1
Specialties								
VC1009-1W/Y	Spec	6	606	71.2	3.3	1.084	1.9	1.2
VC1123-2W/Y	Spec	5	570	89.0	3.2	1.089	2.5	4.7
AC97521-1R/Y	Spec	4	610	80.4	3.0	1.090	0.5	1.1
CO97226-2R/R	Spec	4	374	40.2	2.3	1.081	0.2	0.0
CO97232-1R/Y	Spec	4	436	72.3	2.1	1.081	0.6	0.0
CO97232-2R/Y	Spec	4	448	87.1	2.7	1.070	0.8	1.1
CO97233-3R/Y	Spec	4	509	74.9	3.5	1.082	4.6	3.5
All Blue	Spec	10	531	63.0	3.0	1.084	0.7	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	18	407	88.2	1.8	1.085	2.0	0.7

Table 2 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 - 2006. Advanced selections that may be released for grower evaluation in 2007 are highlighted.

Clone	Usage ¹	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity ²	Specific Gravity	% External Defects ³	% Hollow Heart ⁴
Chippers								
CO95051-7W	Chip	6	418	86.5	3.4	1.098	1.1	0.3
CO96141-4W	Chip	5	421	89.2	2.8	1.087	1.5	0.0
CO97043-14W	Chip	4	418	85.9	2.9	1.088	1.8	0.5
CO97065-7W	Chip	4	418	87.8	2.6	1.097	0.9	0.2
Atlantic	Chip	31	455	87.2	3.2	1.097	2.8	5.6
Chipeta	Chip	29	533	83.8	3.3	1.089	5.5	0.6

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.