Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2005
AND RESEARCH PROPOSAL FOR 2006

Submitted to:

Colorado Potato Administrative Committee (Area II) - Research Committee

Title:

Potato Breeding and Selection for Colorado

Project Leaders:

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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.

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, specialty, and chippers) 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 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. In 2005, with the addition of the new building at the SLV Research Center, we worked on finishing laboratory and storage facilities for use last fall. These facilities are a great addition that will support 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:

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 2005 will be available for grower evaluation in 2016. 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 2005:

The following is a brief summary of research conducted in 2005. A complete research progress report for 2005 will be presented at the research reporting meeting on March 1, 2006.

One hundred parental clones were intercrossed in 2005 in two separate crossing blocks. The emphasis of the first crossing block was specialty cultivar development and PVY and late blight resistance. The second emphasized russets, reds, specialty, and PVY immunity. Seed from 279 combinations was obtained.

Approximately 56,302 seedling tubers representing 219 families were produced from 2003 and 2004 crosses, for initial field selection in 2006. These seedlings represent crosses segregating primarily for russet, reds, chippers, 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 85,007 first-year seedlings in 2005, with 848 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, College Station, Texas. Another 789 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 254 were saved for further observation. Fifty-three advanced selections were saved at harvest and will be increased in 2006 pending final evaluations.

Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers, included 7 russets (AC92009-4RU, CO93001-11RU, AC96051-1RU, CO94035-15RU, CO95086-8RU, CO95172-3RU, and TC1675-1RU), 4 reds (CO93037-6R, CO97078-5R, NDC5281-2R, and VC1075-1R), 5 chippers (AC97097-14W, CO95051-7W, CO96141-4W, CO97043-14W, and CO97065-7W), and 11 specialty selections (AC97521-1R/Y, CO94157-2W/Y, CO97226-2R/R, CO97232-1R/Y, CO97232-2R/Y, CO97233-3R/Y, VC0967-2R/Y, VC1002-3W/Y, VC1009-1W/Y, VC1015-7R/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). Two selections, AC92009-4RU and NDC5281-2R, will be named in the near future. AC92009-4RU is a fresh market selection with excellent tuber type and a long dormancy. NDC5281-2R 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.

PVP is pending for Keystone Russet, Silverton Russet, Colorado Rose, Rio Grande Russet, Mountain Rose, and Purple Majesty.

A total of 202 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.

The following collaborative studies were conducted in 2005:

- Advanced selections were evaluated for disease symptom expression in cooperation with Rob Davidson, Andrew Houser, Kent Sather, and Rick Haslar. Included were: bacterial ring rot (33), potato leafroll virus (20), PVY (22) and powdery scab (17) in Colorado.

- Ten fourth year selections and all of the Southwestern Regional Trial entries were screened for late blight resistance by Oregon State University.

- Several advanced selections were sent to Michigan, Oregon, 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).

- 69 selections and named cultivars from 2005 are being screened for antioxidant activity and vitamin C in cooperation with Cecil Stushnoff.

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

- A new study was initiated with Jorge Delgado, USDA-ARS, and Cecil Stushnoff to examine the mineral element content and vitamin C content for 105 clones. 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 2006: (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 developing 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 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. 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* breast and colon cancer cell culture studies 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 program. Initial focus will included PVY, powdery scab, and pink rot.

6. Expand the use of on-farm trials to: (1) assistant 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)]. The goal would be to develop an annual report summarizing results specific to this set of trials. This will be a collaborative effort with Rob Davidson and Samuel Essah.

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 nutritent-use efficiency will continue.

Budget Request for 2006:

Request*	$60,500	
Research Associate	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

*This request is the same as proposed in 2005.

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 2. Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects - 2005. Advanced selections that may be released for grower evaluation in 2006 are highlighted.

Clone	Usage[1]	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity[2]	Specific Gravity	% External Defects[3]	% Hollow Heart[4]
Russets								
AC92009-4RU	FM	10	387	89.4	3.1	1.096	1.3	0.0
CO94035-15RU	Dual	6	416	85.5	3.0	1.082	2.1	2.4
CO95086-8RU	Dual	5	375	81.6	2.2	1.086	1.2	0.0
CO95172-3RU	FM	5	510	80.9	3.3	1.088	1.3	0.5
AC96052-1RU	**Dual**	**4**	**467**	**86.5**	**3.4**	**1.088**	**1.2**	**0.2**
Centennial Russet	FM	35	294	77.4	3.0	1.080	0.8	0.3
Rio Grande Russet	FM	11	525	82.5	3.1	1.086	3.5	0.5
Russet Norkotah	FM	59	369	84.3	1.8	1.078	2.1	0.4
Russet Nugget	Dual	56	438	81.0	3.8	1.093	1.6	0.2
Reds								
NDC5281-2R	FM	10	404	56.4	1.8	1.087	0.7	0.0
Colorado Rose	FM	12	518	83.7	2.8	1.082	3.0	0.3
Sangre-S10	FM	16	536	87.4	3.5	1.075	2.1	2.1
Specialties								
VC0967-2R/Y	Spec	6	450	84.1	2.5	1.075	0.8	0.1
VC1002-3W/Y	Spec	6	477	50.0	2.8	1.091	0.8	0.2
VC1009-1W/Y	**Spec**	**5**	**616**	**73.8**	**3.4**	**1.084**	**1.9**	**1.4**
VC1123-2W/Y	**Spec**	**4**	**574**	**89.8**	**3.3**	**1.089**	**2.0**	**5.1**
All Blue	Spec	8	526	62.3	3.0	1.084	0.8	0.0
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	16	405	88.1	1.8	1.085	1.9	0.7
Chippers								
CO95051-7W	Chip	5	426	86.3	3.4	1.098	1.1	0.3
CO96141-4W	**Chip**	**4**	**427**	**88.8**	**2.8**	**1.087**	**1.5**	**0.0**
Atlantic	Chip	29	454	86.9	3.2	1.097	2.7	5.3
Chipeta	Chip	27	529	83.7	3.3	1.089	5.4	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.