SUMMARY RESEARCH PROGRESS REPORT FOR 1993
AND RESEARCH PROPOSAL FOR 1994
Submitted to: SLV Research Center Committee
and the Colorado Potato Administrative Committee (Area II)

Title: Potato Disease Studies

Project Leaders: R. D. Davidson and J. L. Whitworth, SLV Research Center

Project Justification:

Managing potato disease problems in the San Luis Valley has become important because of rising production costs and the potential for significant losses when a poor crop is grown. For the last several years a substantial effort has been put forth to reduce the impact of three major disease problems; potato leafroll (PLRV), blackleg (Erwinia spp) and bacterial ring rot (BRR). The certified seed potato program has several intensive programs to eliminate the threat from these disease problems. Success has been varied, but overall, there have been major reductions in the percentage of seed lots with these problems. However, these programs have not eradicated these diseases in the San Luis Valley, primarily because of additional sources of re-contamination which are present. Therefore, continued research with these diseases and others with potential impact in the future, such as PVY, is desirable. The primary emphasis of this project is determining practical, grower oriented methods for control of these diseases.

Project Status:

This is an ongoing project which has been funded at various levels for the past several years. Since the early 1980's, a disease screening program of the newest numbered clones being released by Colorado's Cultivar Development program has been in place. Clones are screened for reaction to BRR and PLRV which includes rating each for symptom development and potential susceptibility to these diseases. Other projects relate to reducing the spread of bacterial diseases, specifically, blackleg. Research projects on seed cutting, use of vine dessicants to reduce tuber recontamination with Erwinia spp. and sources of inoculum have all been funded in the past few years. In addition, there was a special funding of $5000 in 1993 for research dealing with the potential for BRR to remain active in infested soil or nematodes and act as a reservoir for re-infection of seed potatoes. Dr. Gary Franc was a Co-PI on this project. The report for this work will be independent of this particular document.

In 1994 we propose to continue; 1) screening the numbered clones for BRR and PLRV expression, 2) examining the factors behind red color decline in Sangre, 3) examining the use of sulfuric acid in reducing recontamination with Erwinia spp. and PVX/PVS and 4) examining BRR symptom development on microplants grown in the field. In addition, we propose to begin studies on cultural factors contributing to expression and detection of PLRV and PVY in the varieties Chipeta and CO80011-5 (Crestone).

Sangre red color decline project - Co-PI, Richard Zink, SLV Research Center
Microplant BRR symptom expression - Co-PI, Gary Franc, U. of Wyoming

1993 Significant Accomplishments:

Objective 1) Thirteen advanced clones and four established cultivars were screened for their symptom expression to PLRV and BRR. The majority of the clones had adequate, typical expression to BRR. Three clones were of concern. CO86030-1 did not demonstrate any BRR symptoms during the season. CO86142-3 and CO86218-2 had only a small percentage of plants which demonstrated typical symptoms. These clones will need careful testing in 1994 to verify that latency to BRR is not a problem. All of the other clones will also be retested in 1994. Reaction to PLRV was not obtained with several of the clones due to the untimely drift of an insecticide at the time of inoculation. These clones will be retested in 1994. Also in 1994, an additional twenty advanced clones will begin the screening process.

Objective 2) After one year of research some interesting trends in red color decline with Sangre have been found. These trends will be examined more closely in 1994. There were no significant differences in color between seed classes grown (G3 vs. G5) or between fumigated vs. non-fumigated soil. Soils containing the lowest levels of nitrogen produced Sangre with the best red color intensity throughout the season. Also, there did not appear to be any disease problems associated with color decline. Examination of the potatoes during storage has yet to be completed.

Objective 3) This will be the final year of this project. Currently, it appears that sulfuric acid used as a vine dessicant and applied within three days of vine chopping is effective in eliminating spread of Erwinia spp. to daughter tubers. In addition, it appears that this type of treatment will reduce or eliminate the spread of PVX and PVS.

Objective 4) Microplant symptom expression to BRR was examined for the second year. This will be the final year of this project. Stands of microplants inoculated with *Clavibacter michiganensis* subsp. *sepedonicus* (Cms) were not affected in 1993, unlike 1992. More BRR symptoms were apparent in 1993 than in 1992. Overall, the higher the inoculum level, the greater the percentage of plants with BRR symptoms. This relationship also held true for tuber symptoms. Centennial Russet did not demonstrate any foliar symptoms to BRR in either year, yet the level of tuber symptoms was quite high. This was similar in Sangre. Russet Burbank demonstrated excellent BRR foliar symptoms in both years, but had few tuber symptoms. Russet Norkotah had excellent BRR foliar symptoms and tuber symptoms in 1993, but not in 1992. This illustrates how easy it would be for a grower raising contaminated nuclear seed to miss a BRR infection if growing the right cultivar and having the right mix of environmental conditions. For example, a grower raising Centennial Russet would probably not see foliar BRR symptoms. Upon harvest, there is little chance that external evidence of BRR in the tuber would be present. Thus, these contaminated stocks could easily be carried over to the following year.

1994 Objectives:

To continue the above projects as described in the situation statements and to begin work on cultural factors affecting expression of PVY and PLRV in Chipeta and CO80011-5 (Crestone).

Funding Request:	1992 Allocation:	$7,000
	1993 Request:	$1,500

Objective 1: Screening Numbered Clones for PLRV and BRR Symptom Development in the Field.

Thirteen advanced clones and four established cultivars were screened for their symptom expression to bacterial ring rot. The results from 1993 are mixed. The overall infection to BRR was adequate, but not as good as previous years. Part of the problem appears to be a reduction in the virulence of the Cms isolate used. This will be rectified in the future.

All but three clones showed adequate foliar expression to BRR (Table 1). One clone, CO86030-1, did not demonstrate any BRR symptoms during the growing season. Two other clones, CO86142-3 and CO86218-2 had only one or two plants which showed foliar symptoms. These three will be closely observed in 1994. All other clones tested in 1993 will be tested again in 1994.

Tuber symptoms and stem squeezes were not evaluated in 1993 because of the extremely bad condition of the plants late in the season. Tuber yields were very low. A full evaluation will be performed in 1994.

The same advanced clones were screened for symptom expression to PLRV. Table 2 shows results from the individual reactions by clone. Some clones will be re-screened in 1994 because of poor inoculations during the summer of 1993. Natural-in-field spread of PLRV is shown in Table 3. Results indicate that one clone, COTX86146-2, is extremely susceptible to natural-in-field spread of PLRV. This clone, if it continues, should be watched very closely!

Table 1. 1993 Clonal Evaluation for Symptom Expression to Bacterial Ring Rot - Field Symtpoms

	CLONE# AND NAME	DATE OF FIRST SYMPTOMS	# OF REPS +	# OF PLANTS +	PERCENT PLANTS +	DATE 50% OR MORE +	PERCENT PLANTS + 100 DAP	SUMMARY OF SYMPTOMS OVER SEASON
*	ATX84378-1RU	8/6	1	1	4.8	8/16	61.9	ED,W,MN,IVC,IVN
*	CO85026-4	8/6	1	1	4.8	-----	33.3	W,MN,IVC
	BC0894-2	8/16	2	4	19.0	-----	19.0	W,MN,IVC,IVN
	CO86030-1	NONE	0	0	0	-----	0	-----
	CO86051-3	8/16	3	8	38.0	-----	38.0	ED,R,MN,W,IVC
	CO86058-1	7/23	1	1	4.8	8/16	61.9	W,MN,IVC,IVN
	CO86106-4	7/30	1	3	14.3	8/16	80.9	ED,W,MN,IVC,IVN
	CO86142-3	7/30	1	5	23.9	-----	23.9	W,MN,IVC
	CO86153-2	8/16	1	1	4.8	-----	4.8	ED,R,IVC
	CO86218-2	8/6	1	1	4.8	-----	9.5	MN,IVC
	CO86224-1	8/6	3	9	42.9	8/16	61.9	ED,W,MN,IVC,IVN
	ATX85404-8	8/6	1	1	4.8	-----	9.5	W,MN,IVC,IVN
	COTX86146-2	8/6	2	4	19.0	-----	38.0	ED,R,W,MN,IVC
	CENTENNIAL	8/16	1	2	9.5	-----	9.5	W,MN,IVC
	RUSSET BURBANK	7/16	1	3	14.3	-----	19.0	ED,R,W,MN,IVC, IVN
	SANGRE	8/16	1	1	4.8	-----	4.8	IVC
	WNC230-14	7/30	2	3	14.3	-----	14.3	W,MN,IVC

KEY TO SYMPTOMS: ED-early dwarf, R-rosette, IVC-interveinal chlorosis, IVN-interveinal necrosis, MN-marginal necrosis & W-wilt. Planting date - 5/7/93. Last reading taken on 8/16/93, approx. 100 DAP. * Indicates clones previously tested for one year.

Table 2. Leafroll Symptom Expression in Advanced Clones and Standard Cultivars.

Clone/Cultivar	PLRV Rxt (0-3+)	PLRV Symptoms
ATX84378-1RU	---	
CO85026-4	---	
BC0894-2	---	
CO86030-1	2+	LL, CC
CO86051-3	---	
CO86058-1	---	
CO86106-4	3+	LL, CC, WP
CO86142-3	---	
CO86153-2	---	
CO86128-2	---	
CO86224-1	3+	LL, WP, CC
ATX85404-8	3+	LL, CC, WP
COTX86146-2	3+	LL, CC, WP, P
Centennial Russet	3+	LL, Light CC, WP
Russet Burbank	3+	LL, CC, WP
Sangre	3+	LL, CC, WP, P
Russet Nugget	3+	LL, CC, WP

Key - Rating for the symptom expression is 0 for no symptoms to 3 for strong typical symptoms. WP indicates whole plant involvement, LL indicates lower leaf rolling, CC indicates good color change evident (yellowing or bronzing) and P indicates some purpling on leaf margins.

Table 3. Natural-in-field Spread of Leafroll to Advanced Clones and Standard Cultivars.

Clone#/Cultivar	#pos/#emerged	Percent spread	Ave/6 yr.	Risk
ATX84378-1RU	4/60	6.7		Medium
CO85026-4	0/76	0		Low
BC0894-2	0/47	0		Low
CO86030-1	1/59	1.7		Low
CO86051-3	0/67	0		Low
CO86058-1	1/73	1.4		Low
CO86106-4	1/69	1.4		Low
CO86142-3	2/40	5.0		Medium
CO86153-2	0/72	0		Low
CO86128-2	0/75	0		Low
CO86224-1	1/69	1.4		Low
ATX85404-8	2/69	2.9		Low
COTX86142-2	29/48	60.4		High
Green Mountain	4/22	18.2	8.2	Medium
Houma	0/39	0	0	Low
Katahdin	1/73	1.4	2.1	Low
Keswick	0/41	0	4.2	Low
Penobscot	0/38	0	0.3	Low
Russet Burbank	0/66	0	5.8	Medium
Sangre	0/46	0	1.9	Low
Centennial Russet	0/60	0	1.3	Low
WNC230-14	0/48	0	0	Low
Ute Russet	0/69	0	4.8	Medium
Russet Nugget	0/47	0	5.4	Medium

Data for standard cultivars represents an annual collection of two tubers per plant, 12 plants per replication and three replications for each cultivar for a total of 72 tubers planted per clone in each year. Advanced clones have been tested for one year only.
Risk assessment - Low = 0-4.9%, Medium = 5.0-9.9% and High = 10.0%+.

Objective 2: Red Color Survey of Sangre Potatoes Grown in the SLV

Parameters:

Fumigation vs. non-fumigation
High limited generation class vs. low class
Rotation - continuous potatoes vs. 2 year

Fields selected: Planting dates approx. May 5-15, 1993.
Harvest dates approx. Sept. 24-Oct. 5, 1993.

A Worley seed - Sangre G3 - first year production after fumigation (1992) - standard rotation (3031SG51)
B Worley seed - Sangre G5 - grown in non-fumigated soil - standard rotation (3031S151)
C SLVRC - Sangre G3 - first year production after fumigation (1992) - standard rotation (3031SO31)
D SLVRC Roguing plot - Sangre G4 - grown in soil fumigated three years ago (1990) - continuous potatoes for the past ten years at least.

Format:

Samples were taken on a periodic basis beginning in late July and continuing through harvest and storage. Samples consisted of selecting three to four representative hills and removing three tubers from each hill. A sample had nine to twelve tubers representative of the size range under the hills at the time of sampling. Tubers were washed and color intensity rated based on a 1-5 scale. Pictures were taken of each three to four tubers in each sample using Kodachrome ASA 25 or 64.

Data:

Color Intensity - 1-5; 1-worst, 5-most intense

Sample #/Date	A	B	C	D
#1-4 7/23/93	5	4	5	5
#5-8 8/05/93	4	3	4	5
#9-12 8/25/93	2	3	4	4
#13-16 9/16/93	2	3	4	4

Comments:

7/23/93 - A has slight color loss from stem end to mid-tuber. All samples showing some degree of browning on the skin similar to light russet scab. Tubers approx. 2-3 oz. in size.

8/05/93 - A has some russetting apparent while D has quite a bit of Rhizoctonia sclerotia present. Tubers approx. 4-6 oz. in size.

8/25/93 - Tubers 8 oz.+ in size. Ranking - A/4, B/3, C/1, D/2

9/15/93 - Vines dead for at least two weeks. Tubers 10 oz.+ in size. All tubers have a rough skin with some russetting apparent in C and D. A and B very bleached out with darker brown areas on the skin (not russetting). Ranking - A/4, B/3, C/1, D/2

Color intensity was similar between classes of seed (G3 vs. G5) and potatoes grown in fumigated vs. non-fumigated soil. No evidence of disease problems (silver scurf, scab, etc.) were detected in any of the samples. Color intensity was greatest on potatoes grown in soils containing the lowest amounts of nitrogen. Fertility may be the significant factor causing the red color decline. Research for 1994 will concentrate on this factor of production.

Objective 4: Symptom Development with Microplants Grown in the Field and Inoculated with Three Levels of Bacterial Ring Rot.

Project Leaders: Robert Davidson & Gary Franc

Bacterial ring rot (BRR) of potatoes caused by *Clavibacter michiganensis* subsp. *sepedonicus* (Cms) has been a serious disease in the San Luis Valley for decades. Recently, programs designed to clean up seed stocks by using tissue culture derived sources of seed have been implemented in the Colorado seed program as well as most other areas of North America. These programs have proven extremely successful, however, there have still been many unexplained cases of BRR in seed stocks derived from these clean sources after two or three years in the field. This inability to eradicate BRR suggests that there are unidentified sources of Cms inoculum which exist. BRR symptom development of infected microplants was examined under normal growing circumstances.

Russet Burbank, Sangre, Russet Norkotah and Centennial Russet were root inoculated with three levels of Cms (zero, 10^2 and 10^8 cfu/ml) as microplants. Four replications of between ten to fifteen plantlets of each cultivar at each inoculum level were planted in a randomized complete block design. All treatments were grown at two locations; the San Luis Valley and Torrington, Wyoming, representing two very distinct growing environments. Because of insect problems (pysllid) and poor environmental conditions, only results from the San Luis Valley site were obtained in 1992 and 1993.

In 1992, but not 1993, there were significant differences in plant stand between cultivars and inoculum treatments (Table 1). Stands of Russet Burbank and Sangre were close to 100% regardless of the treatment or the number of days after planting. Stands of Russet Norkotah and Centennial Russet decreased incrementally from the control to the highest inoculum levels. The longer the microplants were in the field, the greater the stand reduction. The most severe reductions were seen in the Cms inoculated treatments. It is not uncommon for BRR symptoms to be expressed in the field in a hypersentive manner, i.e., plant death over time. The significant decrease in stands of both Russet Norkotah and Centennial Russet should be considered a visible, yet difficult to detect, symptom of BRR. Both of these cultivars are also known to produce latent reactions to BRR under certain circumstances.

Visual foliar BRR symptoms were seen only in the highest inoculum level in the Russet Burbank microplants in 1992 and in Russet Burbank, Sangre and Russet Norkotah under both inoculum levels in 1993 (Table 2). Centennial Russet did not demonstrate visual foliar symptoms of BRR in either year. Sangre also showed low levels of symptoms in both years. First symptoms were visible 45 days after planting in 1992 and within 35 days after planting in 1993. Symptoms included early dwarf, rosette, interveinal chlorosis, marginal necrosis and plant death. All are common symptoms of BRR foliar expression. It should be noted that BRR symptoms were found much earlier in the season than normal expression within grower's fields.

Tuber symptoms were seen in all cultivars in both years, but only scored on a percenatage basis in 1993. Russet Burbank, while demonstrating excellent foliar symptoms, had no tuber symptoms at the low inoculum level and only 7% of the tubers showed symptoms at the high inoculum level. Sangre, on the other hand, had poor foliar symptoms, yet had tuber symptoms evident at both inoculum levels. Russet Norkotah had both good foliar symptoms and excellent tuber symptoms. Finally, Centennial Russet had no foliar symptoms coupled with excellent tuber symptoms, on par with Russet Norkotah. As inoculum increased, percentage of tubers with symptoms increased. It is interesting to note the significant variation between cultivars when comparing foliar symptom expression to tuber symptom expression.

It is quite evident that microplants infected with very high levels of Cms could go undetected through the summer (see Centennial Russet) and probably undetected after harvest if tubers were not cut. In some instances, growers would be hard pressed to verify a BRR infection only on the basis of reduced tuber numbers and yields associated with BRR. Another important point is the

time to look for BRR symptoms with certain cultivars. Foliar symptoms in Russet Burbank are fairly straightforward, but tuber symptoms are not. The reverse is true with Centennial Russet. Because of these differences, growers must utilize both growing season and tuber harvest to examine stocks for BRR infection. This should be very apparent to the PCS and its inspectors as well!

Table 1. Microplant Percent Stand in the San Luis Valley, 1992/93.

Treatment	1992 35 DAP	1992 56 DAP	1993 40 DAP
RB zero	100	100	98
RB 10^2	100	100	98
RB 10^8	100	100	100
SG zero	100	100	95
SG 10^2	100	100	100
SG 10^8	100	100	100
NK zero	100	89	93
NK 10^2	96	75	93
NK 10^8	78	28	88
CR zero	87	64	90
CR 10^2	57	5	95
CR 10^8	66	16	83

DAP - days after planting, Planting dates - 6/23/92 & 7/6/93 Harvest dates - 9/15/92 & 9/15/93

Table 2. Percent of Plants and Harvested Tubers (1993 only) Expressing Bacterial Ring Rot Symptoms in the San Luis Valley.

Treatment	% Plants with Symptoms		% Tubers with Symptoms
	1992	1993	1993
RB zero	0	0	0
RB 10^2	0	23	0
RB 10^8	79	63	7
SG zero	0	0	0
SG 10^2	0	3	4
SG 10^8	0	3	22
NK zero	0	0	0
NK 10^2	0	19	8
NK 10^8	0	60	45
CR zero	0	0	0
CR 10^2	0	0	10
CR 10^8	0	0	36

Data summarized across four replications. Up to a maximum of five tubers/plant, depending upon the numbers of tubers harvested were examined for bacterial ring rot symptoms. Final disease readings taken 56 DAP in 1992 and 40 DAP in 1993.

Table 3. Number of Tubers Harvested per Plant in the San Luis Valley.

Treatment	Number of Tubers/Plant	
	1992	1993
RB zero	7.2	9.1
RB 10^2	8.1	8.9
RB 10^8	4.0	7.3
SG zero	4.3	8.5
SG 10^2	3.9	8.2
SG 10^8	3.8	7.4
NK zero	2.2	2.1
NK 10^2	1.7	2.5
NK 10^8	1.2	2.1
CR zero	1.4	2.2
CR 10^2	1.5	2.7
CR 10^8	1.0	2.8