1982-1983

Annual Report

to the

Area II Potato Administrative Committee

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I. Evaluation of 11 potato clones in the fall 1981 and spring 1982 in respect to ascorbic acid content, redox potential, dry matter content, blackspot, soft rot susceptibility and elemental composition.

This work had a 2 fold objective. First to provide information on the storage behavior of promising clones and second to determine the effects of storage on the relationships between the six factors mentioned above. The study began after the fall harvest in 1981 and was completed in May of 1982 following storage of the potatoes at $4^{o}C$. Procedures were similar to those described in prior reports.

Results

The cultivars varied considerably in all factors measured (tables 1, 2, 3). Ascorbic acid varied from 15 to 31 mg per 100 grams in the fall 1981 and from 9 to 16 mg in the spring 1982, (table 1). Thus, the mean decrease in ascorbic acid during storage at $4^{o}C$ was about 50%. Dry matter content also varied greatly, from 21.8 to 28.4, but did not change significantly during storage. The blackspot index, which incorporates both the darkness of the color and percent of bruised loci showing color, varied from 0 to 225 on a scale from 0 = resistant to 225 = maximum susceptibility. About 50 percent of the cultivars became more blackspot susceptible during storage at $4^{o}C$ while the rest became less susceptible. The mean blackspot volume also varied greatly between cultivars and the change in volume resulting from storage at $4^{o}C$ also varied between cultivars.

Cultivar redox potential ranged from 44 to 80 in the fall and 61 to 130 following $4^{o}C$ storage. All cultivars, to various degrees, increased in redox potential during storage at $4^{o}C$. This suggests that the overall redox systems became more oxidative. Partially, this may be related to the decrease in ascorbic acid content. The observed differences in redox potential between the bud, middle and stem end of the tuber were not statistically significant. Likewise the slight differences between readings taken

15, 30 and 60 seconds after placing the electrodes were not significant.

Cultivars differed greatly in soft rot susceptibility (table 3). Susceptibility did not change during storage at $4^{o}C$ when the inoculated tissue discs were incubated in air. However, a marked increase in susceptibility occurred when the inoculated tissue discs were incubated in 8% CO_2; then the soft rot index increased during storage from 72 to 173 where 200 equals maximum susceptibility. The blackspot susceptibility index of one clone, WC567-1, increased from 0 to 192 when tissue discs were incubated in 8% CO_2 while in air the index only increased from 22 to 29.

The relationship between the factors shown in tables 1, 2, 3 and the percentage potassium and calcium was examined using linear correlation analyses. Table 4 shows all possible correlation coefficients, their level of significance and whether positively or negatively correlated. In some cases the correlations are not relevant. It should also be noted in table 4 that some correlations were significant in the fall while not in the spring and vice versa. All significant and relevant correlations have been taken from table 4 and summarized in table 5.

As mentioned above, ascorbic acid and redox were inversely correlated. Blackspot color was inversely correlated with redox potential in the fall 1981 and positively correlated with ascorbic acid in the spring 1982. In theory, blackspot color should be positively correlated with decreasing redox and negatively correlated with increasing ascorbic acid since both indicate more reducing conditions. Blackspot color in the fall 1981 was positively correlated with calcium.

The percentage dry matter in the fall 1981 and spring 1982 was positively correlated with the respective blackspot indexes.

The percentage potassium was inversely related to dry matter, blackspot color, index and volume and to soft rot susceptibility when inoculated tissue discs were incubated in either air or 8% CO_2.

Blackspot color, index or volume was positively correlated with soft rot susceptibility in a number of comparisons.

The tuber elemental composition of the 11 clones is shown in table 6. The clones differed significantly or highly significantly in the percentages of potassium, zinc, and calcium. No significant differences occurred between clones in the percentages of iron, copper, manganese or phosphorus. The ratio of potassium to calcium varied widely between cultivars and related significantly and inversely to the blackspot index ($r = -0.47^*$). Potassium and calcium, however, were not significantly correlated. Calcium and magnesium also were not correlated.

Table 1
Ascorbic acid content, % dry weight, and blackspot susceptibility of 11 clones in the fall 1981 and spring 1982 following tuber storage at 4°C.

Cultivar	Mg/100 g ASC Acid		% Dry Wt.		BLACKSPOT % Loci Discolored Stem		Mid		Bud		Color[a]		Index[b]		Mean Vol.[c] (of spot)	
	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82
AC67560	21	9	21.8	22.1	50	20	30	30	80	10	1.3	1.0	69	20	370	88
BC9020-7	21	11	24.6	24.4	20	80	20	30	20	10	1.0	1.4	28	56	52	133
BC9071-6	19	10	22.5	24.5	50	30	50	20	70	0	1.0	1.0	57	17	322	178
BC9289-1	15	9	22.7	23.0	30	0	10	0	20	0	1.0	0.0	20	0	99	0
WC230-14	27	10	23.3	23.8	10	20	0	30	10	0	1.5	1.8	10	30	86	251
WC521-12	22	9	28.4	28.8	90	70	80	70	80	40	1.8	1.4	150	84	270	207
WC567-1	31	14	21.8	23.9	10	40	10	20	0	10	2.0	2.3	13	54	87	429
WC630-2	27	13	22.7	25.8	60	30	10	0	30	0	1.5	1.3	50	13	125	59
Centennial	25	16	22.3	23.8	20	40	0	10	30	10	1.4	1.8	23	36	65	132
Lemhi	24	14	24.7	26.0	80	100	30	80	100	80	3.0	2.6	210	225	398	313
R. Burbank	17	10	24.3	24.9	60	30	20	40	60	30	2.3	1.9	107	63	119	116
Means	22.6	11.2	23.6	24.6	44	42	24	31	45	18	1.6	1.5	67	54	181	173
Significance	<.01	<.01	<.01	<.01												

[a] Darkness increases with increasing value.

[b] Index = mean % loci showing color x color; 0 = resistant, 300 = maximum severity.

[c] Mean value in cubic millimeters based on a cylinder.

Table 2
Redox potential of 11 clones measured with a platinum electrode and a Ag-AgCl reference electrode in the fall 1981 and spring 1982 following tuber storage at 4°C. Values are referenced to saturated quinhydrone at pH 4 set equal to zero.

Cultivar	Stem		Mid		Bud		15 sec.		30 sec.		60 sec.		Mean	
	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82	F'81	S'82
AC67560	83	118	86	110	72	118	78	116	77	113	85	117	80	115
BC9020-7	71	125	64	136	65	131	68	169	66	124	66	97	66	130
BC9071-6	65	61	53	60	62	60	64	60	59	60	59	63	60	61
BC9289-1	81	90	77	89	71	99	78	104	74	88	77	86	76	93
WC230-14	80	82	70	74	58	68	70	72	67	73	72	78	69	74
WC521-12	71	99	65	95	70	98	70	110	68	94	69	88	69	97
WC567-1	52	83	52	76	62	79	56	80	52	77	58	82	55	80
WC630-2	72	73	57	76	48	77	58	76	57	74	62	76	59	76
Centennial	74	66	61	76	62	87	64	76	62	74	71	78	66	76
Lemhi	61	73	41	73	30	88	47	78	43	77	42	80	44	78
R. Burbank	77	99	71	79	60	90	66	85	67	88	75	94	69	89
Mean	72	88	63	86	60	90	65	93	63	86	67	85	65	88
Significance	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table 3
Soft rot susceptibility of 11 clones in the fall 1981 and spring 1982 following storage at 4°C. Susceptibility evaluated with tissue discs inoculated with Erwinia atroseptica and incubated at 23°C in air and 8% CO_2.

Cultivar	Fall 1981[b]		Spring 1982[b]		Mean	
	Air	8% CO_2	Air	8% CO_2	Air	8% CO_2
AC67560	171[a]	150	157	197	164	174
BC9020-7	35	45	72	174	54	110
BC9071-6	177	159	157	200	167	180
BC9289-1	31	11	15	82	23	47
WC230-14	63	77	109	200	86	139
WC521-12	176	119	117	200	147	160
WC567-1	22	0	29	192	26	96
WC630-2	88	52	58	200	73	126
Centennial	25	19	2	107	14	63
Lemhi	150	115	125	200	138	158
R. Burbank	83	43	144	155	114	99
Means	93	72	90	173	92	123

[a]Soft rot index ; 0=200; 0=complete resistance, 200=maximum susceptibility.

[b]Correlations between fall and spring readings were as follows:
(r) air fall 1981 versus spring 1982 = 0.82**
(r) 8% CO_2 fall 1981 versus spring 1982 = 0.61**

Table 4

Linear correlation coefficients observed between factors measured in the fall of 1981 and spring 1982 following tuber storage at 4°C.[a]

Factors	FACTORS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. As. Acid F'81		.64	-.50	-.30	-.18	.10	.30	.64	-.17	.15	-.18	.67	-.23	-.29	-.20	-.46	-.27	.09	.05	-.35
2. " " S'82			-.66	-.37	-.29	.00	.36	.62	-.03	.33	-.22	.39	-.40	-.54	-.42	-.09	-.49	-.17	-.41	-.12
3. Redox F'81				.49	-.05	-.39	-.62	-.69	-.41	-.68	-.19	-.65	-.05	.03	.00	-.39	.00	-.18	-.09	.09
4. " "S'82					.25	-.13	-.24	-.25	.00	-.04	-.07	-.30	-.07	.04	-.03	-.07	.00	-.05	.03	.00
5. % DM F'81						.86	.32	.14	.63	.47	.19	.09	.36	.28	.24	.22	.34	.26	-.56	.13
6. " S'82							.43	.29	.65	.48	.21	.22	.40	.18	.21	.37	.31	.31	-.43	.07
7. BS Color F'81								.79	.74	.84	.32	.56	.19	.23	.03	.29	.22	.15	-.43	.42
8. " " S'82									.38	.69	.05	.78	-.03	-.10	-.06	.43	.03	.16	-.23	.24
9. BS Index F'81										.83	.72	.20	.67	.54	.51	.34	.64	.49	-.57	.24
10. " " S'82											.47	.53	.30	.25	.22	.30	.29	.28	-.34	.09
11. BS Vol. F'81												.13	.92	.71	.87	.49	.86	.79	-.55	.15
12. " " S'82													.00	.06	.00	.51	.04	.25	-.39	.13
13. S. Rot Air F'81														.82	.95	.59	.96	.88	-.63	.05
14. " " S'82															.85	.64	.95	.84	-.51	.03
15. S. Rot CO_2 F'81																.61	.94	.93	-.53	-.18
16. " " S'82																	.64	.86	-.40	-.14
17. S. Rot $\bar{X}$ F'81																		.90	-.64	.12
18. " " S'82																			-.53	-.18
19. % K																				-.18
20. % Ca																				

[a]Values > .42 sig. at 5% level.
Values > .54 sig. at 1% level.

Table 5

Summary of significant or highly significant correlations between factors shown in table 4.

Factors	r
As. Acid F'81 - As. Acid S'82	+0.64**
As. Acid F'81 - Redox F'81	-0.50*
As. Acid S'82 - BS Color S'82	+0.62**
Redox F'81 - Redox S'82	+0.49*
Redox F'81 - BS Color F'81	-0.62**
% DM F'81 - % DM S'82	+0.86**
% DM F'81 - BS Index F'81	+0.63**
% DM F'81 - %K	-0.56**
% DM S'82 - BS Index S'82	0.48*
% DM S'82 - %K	-0.43*
BS Color F'81 - BS Color S'82	+0.79**
BS Color F'81 - BS Index F'81	+0.74**
BS Color F'81 - %K	-0.43*
BS Color F'81 - % Ca	+0.42*
BS Color S'82 - BS Index S'82	+0.69**
BS Color S'82 - BS Volume S'82	+0.78**
BS Color S'82 - Soft rot CO_2 S'82	+0.43*
BS Index F'81 - BS Index S'82	+0.83**
BS Index F'81 - BS Vol. F'81	+0.72**
BS Index F'81 - Soft rot air F'81	+0.67**
BS Index F'81 - Soft rot CO_2 F'81	+0.51*
BS Index F'81 - % K+	-0.57**
BS Index S'82 - BS Vol. S'82	+0.53*
BS Vol. F'81 - Soft rot air F'81	+0.92**
BS Vol. F'81 - Soft rot CO_2 F'81	+0.87**
BS Vol. F'81 - %K	-0.55**
BS Vol. S'82 - Soft rot CO_2 S'82	+0.51*
Soft rot air F'81 - Soft rot air S'82	+0.82**
Soft rot air F'81 - Soft rot CO_2 F'81	+0.95**
Soft rot air F'81 - K+	-0.51*
Soft rot CO_2 F'81 - Soft rot CO_2 S'82	+0.61**
Soft rot CO_2 F'81 - K+	-0.53*

Table 6
Tuber elemental composition of 15 clones studied during 1980-81 storage year.

Cultivar	Ratio K/Ca	%K	PPM Fe	PPM Cu	PPM Zn	PPM Mn	%P	%Ca	%Mg
AC67560	36	1.632	10.6	8.98	17.1	4.73	.11	.0453	.088
BC9020-7	49	1.815	12.7	8.47	18.8	5.63	.12	.0367	.092
BC9071-6	44	1.688	11.8	9.36	15.1	4.44	.10	.0382	.078
BC9289-1	43	1.763	13.3	5.52	14.6	5.85	.14	.0407	.099
WC230-14	26	1.658	9.9	5.88	12.8	5.48	.11	.0645	.077
WC521-12	26	1.503	10.8	10.27	16.4	4.45	.12	.0574	.069
WC567-1	27	1.682	14.4	9.31	19.1	4.46	.15	.0613	.095
WC630-2	24	1.825	16.3	9.60	19.3	5.79	.12	.0756	.096
Centennial	19	1.767	15.5	9.20	18.2	5.81	.13	.0934	.098
Lemhi	15	1.655	16.3	10.13	21.9	5.04	.12	.1068	.093
R. Burbank	17	1.643	15.1	10.55	21.7	6.84	.13	.0987	.098
Means		1.688	13.78	9.19	22.79	5.34	.13	.0650	.090
Significance		.01	.05	.01	NS	NS	NS	.01	.01
BC8524-3	24	1.970	13.8	6.85	9.7	5.13	.14	.0815	.113
WC708-6	32	1.525	9.7	11.34	13.2	4.98	.12	.0475	.088
WC612-13	32	1.480	11.3	11.95	17.6	5.54	.14	.0465	.091
WC672-2	30	1.610	9.8	9.34	13.1	5.31	.11	.0540	.103
Means		1.646	11.14	10.03	13.38	5.24	.13	.057	.098
Significance		.01	NS	NS	.05	NS	NS	.01	NS
Reported Values		to 1.394 2.895	to 30 85	to 6 28	to 17 22	to 1.8 85	to .043 .605	to .01 .12	to 046 .216

II. Evaluation of 9 potato clones in the fall 1982 in respect to soft rot susceptibility, redox potential, blackspot susceptibility, dry matter content and ascorbic acid content.

The 9 potato clones included, the two standards, Centennial and Russet Burbank, one clone, WC285-18, in the program for several years, and six recently selected promising clones.

Results

All clones were quite susceptible to soft rot (table 7). Significant differences in soft rot susceptibility were not observed between clones nor between air and 8% CO_2. In contrast to prior observations, Centennial was also highly susceptible to soft rot. A slight modification in the application of the inoculation to the discs and a different strain of Erwinia atroseptica used in the fall of 1982 may have been responsible for the difference.

Highly significant differences in redox potential were observed between clones (table 8). The means of the stem, mid and bud end measurements ranged from 67 to 108.

The blackspot index of the 9 cultivars varied from 60 to 300 (table 9). Two new clones and Russet Burbank shattered very badly when impacted with the falling weight. Centennial and the other 5 clones exhibited light to medium shatter. TC2-1 clone was unique in exhibiting very low color development and light shatter.

Table 10 presents the mean redox, soft rot index, and blackspot volume, color and index from (tables 7, 8 and 9) and the percent dry matter and ascorbic acid content. Highly significant differences between clones in dry matter and ascorbic content occurred. Linear correlation coefficients comparing some of the factors are shown at the bottom of table 10. To compare clones studied in 1981 with the new clones some coefficients are included from table 4. The only comparable coefficient was that between ascorbic acid and redox potential. A value of -0.50* was obtained with the new clones compared to -0.50* (fall 1981) and -0.37 (spring 1982).

A negative and significant correlation was observed in the fall 1982 between ascorbic acid and blackspot color. In the spring 1982 (different clones) the correlation was also significant but positive. No other correlations were significant in the fall 1982. Further data on the 9 clones will be obtained this spring and a more complete data analyses including the elemental composition will be done.

Table 7

Soft rot susceptibility of 9 clones in the fall of 1982. Susceptibility evaluated with tissue discs inoculated with Erwinia atroseptica and incubated at 23°C in air and 8% CO_2.

	Percentage in Each Category[a]								Index[b]	
	0		1		2		3			
Cultivar	Air	8% CO_2	Air	8% CO_2	Air	8% CO_2	Air	8% CO_2	Air	8% CO_2
AC71861-4	3	2	10	4	0	1	87	92	174	185
AC77562-1	0	0	1	4	1	3	97	93	195	189
AC77149-2	0	0	5	17	4	0	91	83	186	166
AC77514-1	11	5	1	3	4	0	84	92	172	184
Centennial	14	6	0	19	11	4	75	72	161	148
R. Burbank	20	6	0	0	7	1	73	93	153	187
WC285-18	15	0	2	8	8	1	75	91	158	183
AC7751-1	4	0	1	0	0	0	95	100	190	200
TC 2-1	15	9	8	0	1	9	76	82	153	173
Means	9	3	3	6	4	2	84	89	171	180

F (variety) = 1.026 NS
F (atmosphere) =0.762 NS
F (var. x atm.) =0.817 NS

[a]0=no decay, 1=blister, 2=trace to ½ disc decayed, 3=½ to entire disc decayed.

[b]Soft rot index; 0 to 200; 0=complete resistance, 200=maximum susceptibility.

Table 8

Redox potentials of 9 clones measured with a platinum electrode and a Ag- AgCl reference electrode in the fall 1982. Values are referenced to saturated quinhydrone at pH 4 set equal to zero.

Variety	Stem	Mid	Bud	Mean
AC71861-4	117	84	99	100
AC77652-1	107	86	75	89
AC77149-2	125	100	98	108
AC77514-1	78	61	62	67
Centennial	91	74	91	85
R. Burbank	91	93	89	91
WC285-18	110	79	94	95
AC77513-1	94	66	97	86
TC 2-1	78	60	64	68
Means	99	78	86	88

F (stem) = 5.101**
F (mid) = 3.285**
F (bud) = 4.596**
F (mean) = 6.477**

Table 9
Blackspot susceptibility of 9 clones in the fall 1982.

Cultivar	% Loci Showing Color			Mean Volume of Spot[a]			Color[b]			Mean % Loci	Mean Vol.	Mean Color	Index[c]
	Stem	Mid	Bud	Stem	Mid	Bud	Stem	Mid	Bud				
A71861-4 Light Shatter	50	38	38	245	270	211	2	2	1	42	242	2	71
AC77652-1 Medium Shatter	88	75	63	378	275	328	2	2	2	75	327	2	150
AC77149-2 Medium Shatter Jelly end.	88	88	63	610	621	570	2	2	2	80	600	2	160
AC77514-1 Severe Shatter	100	100	100	1457	1779	1035	3	3	3	100	1430	3	300
Centennial Medium Shatter	63	63	63	148	648	348	2	2	2	63	381	2	126
R. Burbank Severe Shatter	100	100	88	992	1771	949	3	3	3	96	1237	3	288
WC285-18 Light Shatter	25	38	50	318	389	174	2	2	2	38	294	2	76
AC77513-1 Severe Shatter	100	100	88	2328	1892	1362	2	2	2	96	1861	2	192
TC 2-1 Light Shatter	63	38	38	170	449	186	1	1	2	46	268	1	60

[a]Mean volume in cubic millimeters based on a cylinder.

[b]Darkness increases with increasing value.

[c]Index = mean % loci showing color x color; 0 = resistant, 300 = maximum severity.

Table 10

Comparisons of factors presented in tables 5, 6 and 7 with ascorbic acid content, % dry matter, % potassium (K), % calcium (Ca) and % magnesium (Mg). (Fall 1982)

Cultivar	% D.M.	Mg AA 100 gr.	Elemental Comp. %K	%Ca	%Mg	Mean Redox	Soft Rot[a] Index Air	8% CO_2	Blackspot Vol.	Color	Index[b]
A71861-4	19.8	19.6				100	174	185	242	2	71
AC77652-1	21.2	19.0				89	195	189	327	2	150
AC77149-2	20.6	16.2				108	186	166	600	2	160
AC77514-1	22.9	18.7				67	172	184	1430	3	300
Centennial	21.4	18.4				85	161	148	381	2	126
R. Burbank	22.3	12.0				91	153	187	1237	3	288
WC285-18	21.1	16.2				95	158	183	294	2	76
AC77513-1	22.1	20.1				86	190	200	1861	2	192
TC2-1	25.3	23.1				68	153	173	268	1	60
Means	21.9	18.1				88	171	180	738	2	158
Significance	<.01	<.01				<.01	NS	NS	-	-	-
								NS			

[a]Soft rot index; 0 to 200, 0 = complete resistance, 200 = maximum susceptibility.
[b]Blackspot index; 0 to 300, 0 = complete resistance, 300 = maximum susceptibility.

Linear Correlation Coefficients

Factors	Fall '82	Fall '81	Spring '82	Factors	Fall'82	Fall'81	Spring'82
Asc. acid. vs. redox	-0.50*	-0.50*	-0.37	Redox vs. color	0.03	-0.62**	-0.25
Asc. acid vs. BS index	-0.51*	-0.17	0.33	% dry matter vs. BS ind.	0.12	0.63**	0.48
Asc. acid vs. color	-0.71**	0.30	0.62**	Soft rot ind. (air) vs. BS ind.	0.10	0.67**	0.25
Redox vs. BS index	-0.23	-0.41	-0.04	Soft rot ind. (CO_2) vs. BS ind.	0.28	0.51*	0.30

* = Significant 5% ** = Significant 1%.

III. Influence of storage at $4^{o}C$ on blackspot susceptibility of the Russet Burbank cultivar.

Blackspot of Russet Burbank potatoes is frequently detected by shipping point inspectors. The time of bruising which incited the blackspot is unknown. The objective of this study was to compare the influence of bruising tubers before and after storage on blackspot susceptibility.

Procedures

The experiment consisted of the following 4 treatments:

1. Bruise⟶ hold at $28^{o}C$ 36 hours, evaluate.
2. Bruise⟶ store 5 months $4^{o}C$, evaluate upon removal.
3. Bruise⟶ store 5 months $4^{o}C$, transfer to $28^{o}C$ for 36 hours then evaluate.
4. Non-bruised tubers⟶store 5 months at $4^{o}C$, remove from storage, bruise and hold at $28^{o}C$ 36 hours, evaluate.

The experiment was replicated 4 times with 10 tubers per replication. Each tuber was bruised in 3 locations, stem, middle and bud end. Bruising was done by dropping a 150 gram weight with a 1 inch hemi-spherical surface through a distance of 45 centimeters onto the surface of the potato.

Results

The first treatment was done on September 30, 1982 (table 11). Blackspot was moderately severe. Shatter bruising was of medium severity. The remaining treatments will be carried out around mid-March 1983.

Table 11

Influence of storage at 4°C on blackspot susceptibility of the Russet Burbank Cultivar.

Treatments	Rep.	% Loci Discolored						
		Stem	Mid	Bud	Color	Index	Mean Volume	Shatter
Bruise→28°C, 36 hours	1	60	90	60	2.5	175	586	Medium
9/30/82	2	40	90	80	2.3	161	543	"
	3	100	90	90	2.4	224	479	"
	4	50	70	50	2.4	136	384	
Mean		63	85	70	2.4	174	498	
Bruise→4°C, 5 mo.	1							
	2							
	3							
	4							
Mean								
Bruise→4°C, 5 mo.	1							
28°C, 36 hours	2							
	3							
	4							
Mean								
5 Mo., 4°C→bruise→28°C,	1							
36 hours	2							
	3							
	4							
Mean								

IV. Sap darkening studies of blackspot susceptible and resistant clones.

Considerable difference in blackspot susceptibility was noted in the 1981 studies (table 1). The objective of this study was to improve our understanding of why such differences exist. This portion of the study examined the relative rates of sap darkening.

Procedure

The following 5 clones which differ considerably in blackspot susceptibility were selected for study:

1. Centennial
2. BC9289-1
3. R. Burbank
4. Lemhi
5. WC567-1
6. BC9071-6

Complete procedural details will be given in the MS thesis to be completed in early summer, 1983. Briefly, the tissue was ground at $0^{o}C$ in buffer. Part of the ground tissue was filtered to remove cell fragments. The non-filtered extract or filtered extract was then divided into three parts. Immediately, either buffer, sodium thiosulfate or catechol (substrate) was added to each part. All systems were transferred to $28^{o}C$ and shaken occassionally for 60 minutes. The nonfiltered extract was then filtered and the degree of darkening (optical density) of the buffered and catechol system was measured with a spectrophotometer. The sodium thiosulfate system, which did not darken, was used as the reference or blank.

Results

The clones differed in the degree of sap darkening. The differences in darkening were not significant in the absence of cell fragments but were highly significant when cell fragments were present. (table 12, figures 1 and 2). Adding catechol (substrate)

significantly increased sap darkening of all clones. For further analyses of the influence of cell fragments and added substrate on sap darkening see table 13. The presence of cell fragments did not increase the darkening of BC9289-1 sap in the absence of substrate. Sap of the other 5 clones darkened more. In the presence of substrate, the difference between BC9289-1 and other clones was less but still present. The difference between clones was significant at the 5% level (table 14).

Clones also differed significantly in respect to the substrate induced darkening (tables 13 and 14). BC9289-1 showed the greatest increase in darkening. The response to substrate was similar in the presence and absence of cell fragments.

These observations do not entirely explain clonal differences in blackspot susceptibility. BC9289-1 blackspots vary little or not at all. However, Centennial, which is slightly blackspot susceptible, reacted similar to Lemhi, an extremely susceptible clone. Sap darkening indicates the blackspot potential. This potential may not always be expressed in the intact tuber due to clonal differences in cellular characteristics.

Cell fragments from BC9289-1 apparently do not carry the same components carried by cell fragments of the other clones. Possible component differences may be the absence of oxidizing enzymes (ie. peroxidases) or the presence of inhibitors.

Table 12

Optical density of cell extracts from 6 cultivars after 60 minutes at 28°C (82°F) in the absence or presence of cell wall fragments and the absence or pressure of added substrate.

	No substrate added		Substrate Added		
Cultivar	Cell Free	Cell Fragments	Cell Free	Cell Fragments	Mean
Centennial	0.477	0.612	0.946	1.004	0.760
BC9289-1	0.285	0.246	0.697	0.722	0.490
R. Burbank	0.469	0.820	0.909	1.420	0.910
Lemhi	0.444	0.524	0.837	0.989	0.700
WC567-1	0.367	0.445	0.789	0.915	0.629
BC9071-6	0.230	0.266	0.566	0.689	0.438
Means	0.379	0.486	0.791	0.957	

Analyses of Variance

		F required	
Factor	F	.05	.01
Cultivars	15.4**	2.5	3.5
Substrate	149.1**	4.1	7.3
Cell fragments	14.1**	4.1	7.3
Cul. X Sub.	0.26	2.5	3.5
Cul. X Cell frag.	2.9*	2.5	3.5
Sub. X Cell frag.	0.71	4.1	7.3
Cul X Sub X Cell frag.	0.19	2.5	3.5

Table 13

Comparison of the optical density ratios of 6 cultivars in response to the presence or absence of cell wall fragments and the presence or absence of added substrate.

	Factors (See Below)			
Cultivar	2/1	4/3	3/1	4/2
Centennial	1.28	1.07	1.99	1.67
BC9289-1	0.89	1.09	2.51	2.91
R. Burbank	1.77	1.55	1.94	1.77
Lemhi	1.19	1.19	1.88	1.89
WC567-1	1.26	1.18	2.17	2.06
BC9071-6	1.16	1.22	2.47	2.60
Means	1.26	1.22	2.16	2.15

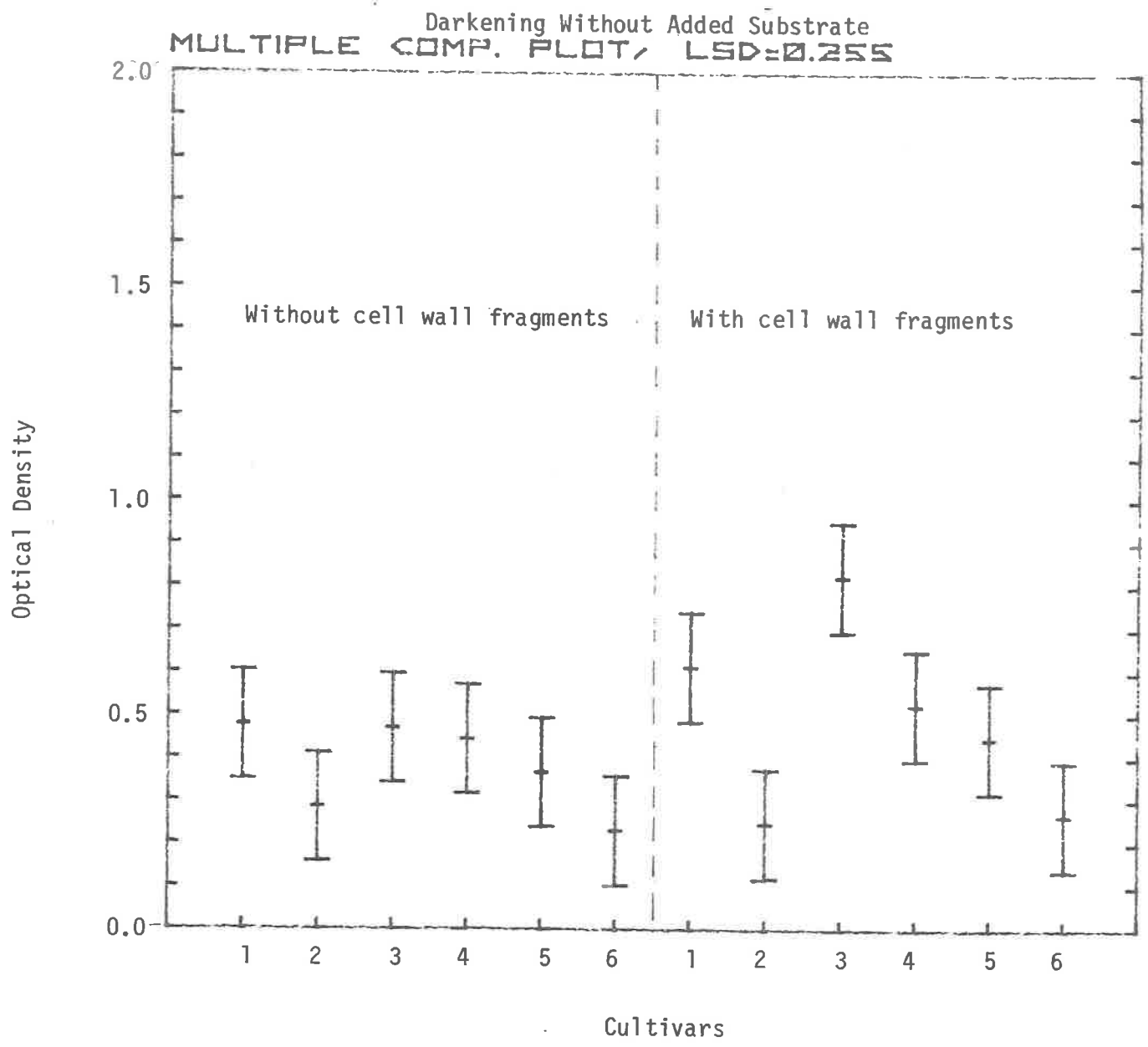
Factors

1. Cell fragments removed, no added substrate.
2. Cell fragments present, no added substrate.
3. Cell fragments removed, added substrate.
4. Cell fragments present, added substrate.

Table 14

Analysis of variance of data presented in table 13.

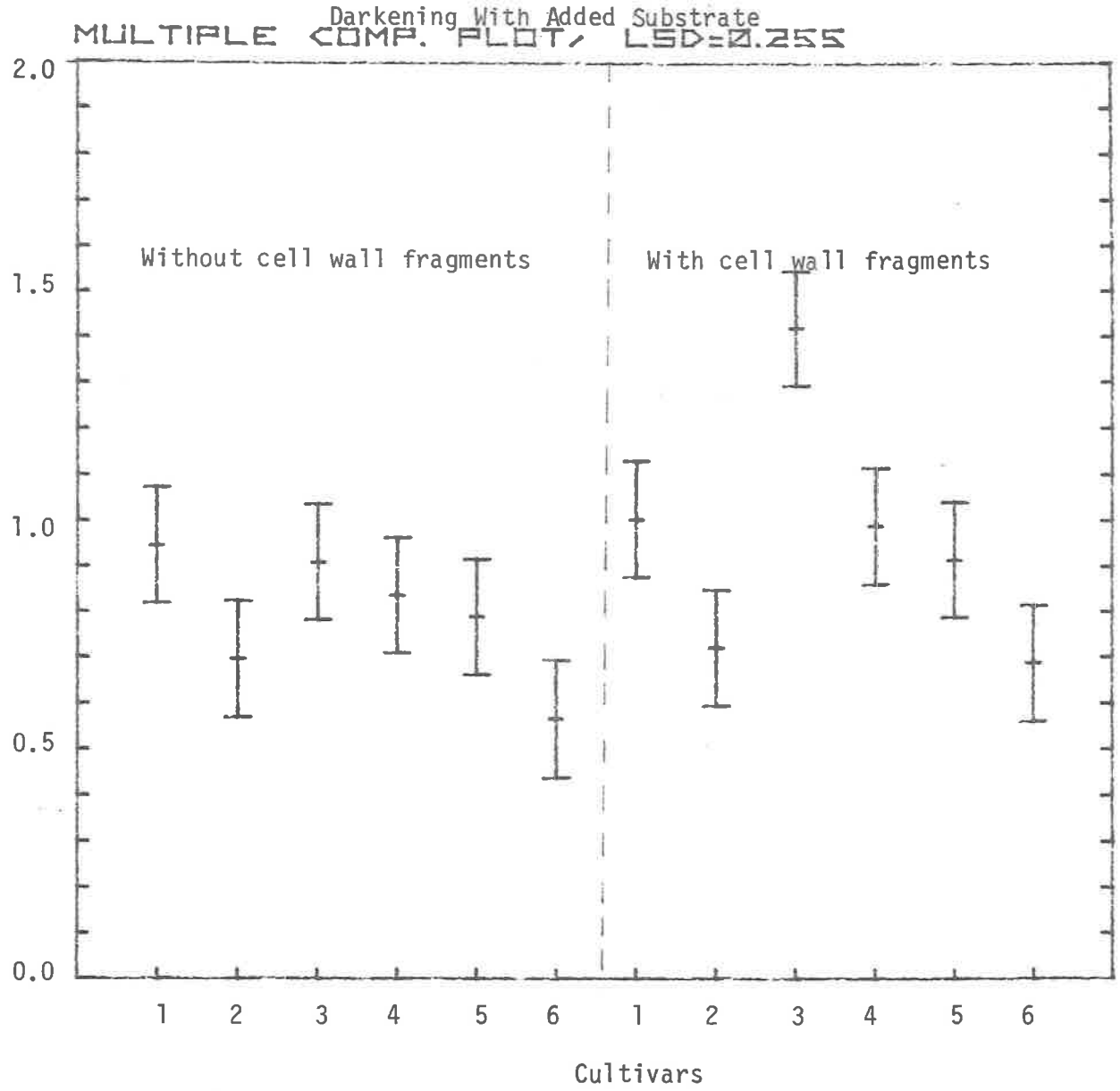
Optical Density Ratios		Condition	F Values and Significance	
			Cultivars	Interaction
2/1	Cell fragments / Cell free	No added substrate	1.49 (NS)	-
4/3	Cell fragments / Cell free	Added substrate	1.35 (NS)	-
	Cell fragments / Cell free	Both	2.64 (.05)	0.34 (NS)
3/1	Added substrate / No substrate	No cell fragments	2.16 (NS)	-
4/2	Added substrate / No substrate	Cell fragments	12.76 (.01)	-
	Added substrate / No substrate	Both	10.35 (.01)	1.15 (NS)



Cultivars

1. Centennial
2. BC9289-1
3. R. Burbank
4. Lemhi
5. WC567-1
6. BC9061-6

Figure 1
Optical density of cell extracts without added substrate after 60 minutes at 28°C (82°F), in the absence and presence of the cell wall fragments.



Cultivars

1. Centennial
2. BC9289-1
3. R. Burbank
4. Lemhi
5. WC567-1
6. BC9071-6

Figure 2.
Optical density of cell extracts with added substrate after 60 minutes at 28°C (82°F), in the absence and presence of the cell wall fragments.

V. Influence of moisture loss and temperature on blackspot and shatter bruise susceptibility of Russet Burbank and WC521-12 clones.

The following observations were noted as part of the experiment described in the following section. An effort was made to condition the tubers to minimize shatter bruising and maximize blackspot. Studies elsewhere have shown that as tuber hydration decreases susceptibility to shatter bruising decreases and blackspot increases.

Tubers of uniform size were carefully weighed. One set of tubers was bruised immediately while other sets were bruised after 48, 96, 144 and 192 hours exposure to room temperature and low humidity. The results are given in table 15. Blackspot of Russet Burbank increased with water loss but non-uniformily. Shatter bruising decreased uniformily with moisture loss. However, nearly 20% shatter bruising still occurred even after moisture loss in excess of 3%.

WC521-12 did not blackspot at any moisture level. This clone decreased slightly in shatter bruising with increased moisture loss. However, depending on bruise severity from 57 to 88% of the tubers still shattered after moisture loss in excess of 4%.

The effect of temperature on susceptibility to blackspot and shatter bruising is given in table 16. Very light blackspot resulted from bruising either Russet Burbank or WC521-12 at tuber temperatures of $4^{o}C$ or $21^{o}C$. Shatter bruising of Russet Burbank was reduced from 60 or 77% to 0% when tubers were warmed from $4^{o}C$ to $21^{o}C$. Shatter bruising of WC521-12 was only slightly reduced when tubers were warmed.

Table 15

Influence of moisture loss on blackspot and shatter bruise susceptibility of the Russet Burbank and WC521-12 tubers.

Cultivar	Treatment	% Weight Loss	Bruising[a] Height (cm)	% Blackspot	% Shatter Bruise	% No Bruise
Russet Burbank	I - 0 hrs.	-	30	0.0	60.0	40.0
			45	0.0	76.7	23.3
	II - 48 hrs.	1.76	30	0.0	36.7	63.3
			45	10.0	63.3	26.7
	III - 96 hrs.	2.48	30	3.3	23.3	73.3
			45	6.7	43.3	50.0
	IV - 144 hrs.	3.64	30	10.0	13.3	76.7
			45	10.0	30.0	60.0
	V - 192 hrs.	3.18	30	3.3	23.3	73.3
			45	16.7	16.7	66.7
WC521-12	I - 0 hrs.	-	30	0.0	93.3	6.7
			45	3.3	96.7	0.0
	II - 48 hrs.	3.12	30	0.0	86.7	13.3
			45	0.0	100.0	0.0
	III - 96 hrs.	4.14	30	0.0	66.7	32.3
			45	0.0	70.0	30.0
	IV - 144 hrs.	4.23	30	0.0	56.7	43.3
			45	0.0	86.7	13.3

[a]150 gram weight

Table 16

Influence of warming tubers of the Russet Burbank and WC521-12 clones on blackspot and shatter bruise susceptibility.

Cultivar	Temperature	Bruising Height (cm)	% Blackspot	% Shatter Bruise	% No Bruise
R. Burbank	4°C (39°F)	30	0	60	40
		45	0	77	23
R. Burbank	21°C (70°F)	30	3	0	97
		45	0	0	100
WC521-12	4°C (39°F)	30	0	93	7
		45	3	97	0
WC521-12	21°C (70°F)	30	0	90	10
		45	0	80	20

VI. Influence of foliage applied chemicals on blackspot susceptibility of the Russet Burbank and WC521-12 clones.

The objective of this study was to screen various foliage applied chemicals to determine their influence on tuber blackspot. The type of chemicals applied and results are shown in table 17. All chemicals were applied as water solutions containing a wetting agent when tubers were of commercial size. Russet Burbank vines were rapidly maturing when the chemicals were first applied.

No significant reduction in blackspot color, index or volume resulted from application of the chemicals. Of the two clones, Russet Burbank showed more severe blackspot than WC521-12.

Table 17

Influence of various foliage applied chemicals on blackspot susceptibility of Russet Burbank (San Luis Valley) and WC521-12 (Lucerne). Tubers evaluated on January 24, 1983 after storage at 4° C.

		Russet Burbank			WC521-12		
Chemical	Type	Mean Color	Blackspot Index	Mean Volume	Mean Color	Blackspot Index	Mean Volume
Water	-	2.0	198	839	1.1	78	451
Ascorbic Acid	Reducing	2.2	213	838	1.0	71	799
Cysteine	Reducing, etc.	1.9	180	684	1.3	110	643
Glutathione	Reducing, etc.	2.1	199	729	1.3	113	675
Sodium Thiosulfate	Reducing	2.1	206	759	1.2	110	577
P-Coumaric Acid	Inhibitor Mixed	1.9	179	679	1.1	100	926
Ferulic Acid	Inhibitor Non-competitive	2.0	188	870	1.0	76	547
2-3 Dihydroxy Napthalene	Inhibitor Competitive	2.1	203	706	1.1	96	484
Thiourea	Copper Complexing	2.1	194	1076	1.1	91	686
Sodium Diethyl dithiocarbonate	Copper Complexing	2.1	208	769	1.1	96	382
Means		2.1	197	794	1.1	94	711
Significance		NS	NS	NS	NS	NS	NS

VII. Summary

1. Eleven clones were evaluated in the fall 1981 and spring 1982 (after $4^{o}C$ storage) for ascorbic acid content, redox potential, dry matter content, blackspot and soft rot susceptibility. Large differences in all factors occurred between clones. Ascorbic acid decreased during storage and dry matter remained constant. Storage either increased or decreased blackspot susceptibility depending on the clone. Soft rot susceptibility did not change during storage when evaluation was made in air but greatly increased when evaluated in 8% CO_2. Linear correlation analyses were done on all factors. The following correlations were the more interesting: The percentage potassium was inversely related to dry matter, blackspot and soft rot susceptibility. Blackspot color, index and volume were positively correlated with soft rot susceptibility in a number of comparisons.
2. In the fall, 1982, 9 clones, including the Russet Burbank and Centennial cultivars, were selected for evaluation. Factors measured were the same as listed above. All clones were highly susceptible to soft rot, including previously resistant Centennial. Redox potential differences between clones were significant. Blackspot and shatter bruise susceptibility, percent dry matter and ascorbic acid also differed significantly. Linear correlation coefficients between factors did not agree well with those obtained in 1981-82.
3. A study to evaluate the influence of $4^{o}C$ ($39^{o}F$) storage on blackspot susceptibility of Russet Burbank is still in progress.
4. The sap darkening characteristics of blackspot resistant and susceptible clones were evaluated. Highly resistant clones showed less sap darkening but moderately and highly

susceptible clones did not differ. The presence of cell fragments did not increase darkening of sap from highly resistant clones but did of moderately resistant and susceptible clones. Sap darkening of resistant clones was increased more from added substrate than that of moderately resistant and susceptible clones.

5. Tubers of Russet Burbank decreased moderately in shatter bruising and increased slightly in blackspot susceptibility with moisture loss in excess of 3%. The clone, WC521-12, did not blackspot at any moisture level and shatter bruising was reduced only slightly with 4% moisture loss. Raising tuber temperature from $4^{o}C$ to $21^{o}C$ eliminated Russet Burbank shatter bruising, but shatter bruising of WC521-12 persisted.
6. Various types of reducing substances and oxidative enzymatic inhibitors were foliage applied to Russet Burbank and WC521-12 to reduce blackspot. No significant differences in blackspot were observed between the chemicals or in comparison to the controls treated with water.