VIRUS FREE SEED PERFORMANCE TESTS IN WASHINGTON

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Introduction

The productive potential of potato virus X (PVX) free and potato virus S (PVS) free seed over that of potato seed infected with these viruses has been reported by several workers. Dowley (1) reviewed some of the reports pertaining to the subject and stated that some workers found little decrease in yield, whereas, others found sizable decreases in yield of potatoes from these latent viruses. The size of the yield reduction appeared to be related to the virulance of the strain of virus, the susceptibility of the variety to the virus, and whether the infection was during the seed year or during the current year. Wright (6) reported results with Russet Burbank and White Rose potatoes in British Columbia, Oregon, California, and Washington. The differences in yield in Washington after the yields were corrected by regression for differences in seed piece size, were not statistically significant. Before yield corrections were applied, the magnitude of the yield differences on a percentage basis was about the same as those reported from the other areas.

Several states have embarked on a PVX and PVS tested potato seed program because of the belief that potato seed free from these viruses has a greater productive capacity than seed infested with these viruses and, therefore, expect to charge more for the seed. If the Washington data are correct and the differences in yield reported by Wright (6) were at least partially due to differences in seed piece size, then an increased value of virus free seed may be difficult to substantiate.

When it comes to comparing seed lots, seed sources, or varieties for yielding potential, the question of what constitutes an adequate check is always paramount because seed piece size, area where grown, degree of dormancy, physiological age and other factors can influence the results. Ohm's compared 5 sources of virus tested seed stocks and found that total yield differed as much as 15% and No. 1 grade tubers differed by as much as 23% (5).

Because of the possibility that virus tested seed available to Washington's commercial potato growers might not be superior to good quality certified seed, further experiments were undertaken to elucidate the problem in 1972 and 1973.

Methods

Seed samples of Russet Burbank potatoes were obtained from Montana and Canada. For each virus tested lot a comparable check lot of seed was obtained. Except in one case in 1973, the check lots of seed and the virus tested lots were produced by the same grower. In 1972 after the samples were collected they were brought to Pullman and placed in 38 F and 90+ R.H. storage from April 13 until cut on May 1 and 2. The storage history of the samples used in 1973 is not known since they were collected at odd times and shipped to Washington in a railroad car loaded with certified seed potatoes shortly before cutting time.

Seed cutting was done with a stainless steel rotary cutting knife which revolved in a 1% solution of Pyrrolidine which was maintained at pH 12 or above to destroy the viruses on the surfaces. The cut seed of both the virus tested and the check lots was accumulated on a stainless steel surface which was kept moist with the Pyrrolidine solution. Technicians wearing rubber gloves kept moist with Pyrrolidine solution counted the seed pieces into nail punctured plastic garbage can liners. One hundred seed pieces were put into each bag and then weighed to keep a check on the precision of the seed cutting operation and to determine the average size of seed piece. The plastic bags proved to be excellent for wound healing and kept the seed pieces from possible contamination from other surfaces.

Planting was done with an assisted feed Iron Age potato planter, the planting parts of which were kept moist with the Pyrrolidine solution. Technicians wore rubber gloves kept moist with Pyrrolidine solution. In 1972 the seed was planted May 8 on land which had never grown potatoes, and in 1973 it was planted March 30 on land which had grown at least three crops of potatoes.

Cultivation was discontinued before the plants came up. When hand weeding was needed, the virus tested lots were weeded first. Freshly cleaned clothing was worn at the beginning of each day, all equipment was kept moistened with Pyrrolidine solution, and the workers wore Pyrrolidine moistened rubber gloves.

Irrigation, insect and disease control were performed as commonly done in commercial practice.

Leaflets were collected from 6% of the plants in each plot in 1972 and from 10% of the plants in 1973. The leaflets were taken about 1/3 of the way up from the bottom of the plants when they were about 2 feet tall. Each leaflet was placed in a separate plastic container with a snap on lid. Pyrrolidine wetted rubber gloves were worn by the workers. Almost immediately after each sample was taken it was placed in a styrofoam cooler containing a cooling agent. The samples were sent by air freight to the University of Montana for serological testing. Each sample was given a number, but the treatment was not identified to the tester.

The experimental design was a modification of a stratified paired plot arrangement. The objectives of the experiment were to evaluate the affect of fertility level on the ability of the analysists to identify PVX and PVS and to determine if potato seed from the PVX and PVS free seed programs was generally more productive than comparable check tubers from a regular certification program. Seed sources were randomly arranged across the field. Each virus free sample was paired with the grower provided check tubers on one side and a paired randomly selected check on the other so that each virus free source of seed could be compared with its own check on one side and a random check on the other. Although possible, the latter comparison was not included in the statistical analysis.

Each individual plot was 2 rows wide, 34 feet long and contained 80 seed pieces per plot. The 3 fertilizer treatments were randomly arranged end to end so that a replication was 3 plots long. These units were repeated 3 times down the field because of a known productivity variable between the two ends of the field.

There was a high level of statistical precision for measuring differences between virus tested and check seed tubers. In 1972 there were 36 and in 1973 there were 54 plots in each mean for determining differences in yielding potential. There was also excellent statistical precision for measuring the main effects of fertilizer and its interactions. The statistical measure for sources of seed was less precise.

A space equivalent to the width of two potato rows was left between all lots of seed to reduce virus contamination during the growing season.

Physical measurements: Specific gravity was determined with a potato hydrometer, blackspot susceptability was determined by dropping a standard weight a fixed distance and reading resultant discoloration with a reflectometer (2) and chip color was determined by frying slices at 375 F until bubbling ceased (3). In 1972 harvesting was completed October 31, specific gravity and blackspot determinations were made March 7 to 9 and chip color was determined after tuber conditioning December 28 to January 9. In 1973 harvesting was completed September 5 and 6 and all of the quality evaluations were made between September 10 to 20.

Results

1972: The results of the statistical analyses are summarized in Table 1. Potatoes grown

from the virus tested seed were statistically higher in specific gravity and lower in blackspot than the check potatoes. Fertilizers affected total yield and specific gravity, but did not interfer with the serological tests.

Table 1. Results of analysis of variance for the factors considered in the 1972 virus tested seed study.[1]

Source	dF	Total Yield	Yield # 1's	% # 1's	Specific Gravity	Black spot	Chip Color
Strata	2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Seed Sources	3	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
(error a)	6						
Virus vs Check	1	N.S.	N.S.	N.S.	***	***	N.S.
VF x Source	3	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
(error b)	8						
Fertilizer	2	*	N.S.	N.S.	*	N.S.	N.S.
F x Source	6	N.S.	N.S.	N.S.	*	N.S.	N.S.
F x VF	2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
F x S x VF	6	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
(error c)	32						
Total	71						

[1] N.S. = nonsignificant at 5% level; * = significant at 5% level; ** = significant at 1% level; *** = significant at .5% level.

Table 2. 1972 Total yield data before and after adjustment to a 50 gram seed piece size.

Source	Yield cwt/acre	Seed Size grams	Adjusted Yield cwt/acre	% Diff
1. VF	942	50.0	942	
CK	923	45.1	928	
Diff	19	4.9	14	1.5
2. VF	894	42.3	901	
CK	911	47.7	913	
Diff	17	5.4	12	1.3
3. VF	930	48.2	932	
CK	921	48.0	923	
Diff	9	.2	9	1.0
4. VF	885	50.7	884	
CK	841	50.4	841	
Diff	44	.3	43	5.1

The total yield data, before and after adjustment for differences in seed piece size, are shown in Table 2. The influence of seed size on yield is apparent. The average size of the seed pieces in seed sources 1 and 2 differed by about 5 grams, a difference not easily discernible, and the differences in yield, though in opposite directions was about 18 cwt, or about 2%.

The adjusted yield of the virus free (VF) seed from seed source 1 was 942 cwt/acre. That of seed source 4 was 884 cwt/acre which was a difference of 58 cwt/acre or about 6%. The adjusted yield of the check seed from seed source 1 was 928 cwt/acre and that from seed source 4 was 841 cwt/acre for a difference of 87 cwt/acre or about 10%. The 44 cwt yield difference for the virus tested seed in source 4 was not significant at the 19:1 level. Thus the differences due to source of seed were larger than the differences in yield due to virus content even though all check sources were much higher in both PVX and PVS, Table 3.

Table 3. Differences in the percentages of the leaflets infected with PVX and PVS among the sources of virus tested and among the sources of check tubers used in 1972.

Source	%PVS	%PVX
1. VF	9	2
CK	40	93
2. VF	0	0
CK	44	96
3. VF	7	0
CK	91	96
4. VF	2	0
CK	60	93
Mean VF	4	1
CK	59	94

The data for the effect of rates of fertilization on the yield of virus tested seed potatoes are in Table 4. On the average there was only a 1% difference in yield between the virus tested and the check seed potatoes. There is a slight indication that as the amount of fertilizer applied increased the difference in yield between the virus tested seed and the check seed became less, but this is believed to be an anomaly of the experiment since the fertilizer X virus content interaction was not significant.

Table 4. Effect of rates of fertilization on the yield of virus tested and check seed potatoes.

	lb/acre 16-16-16			
	1720	2190	2660	Mean
Mean VF	887	929	929	915
Check	846	921	947	905
Difference	41	8	-18	10
% Change	5	1	- 2	1

1973: The results of the statistical analyses for the factors measured are shown in Table 5. There were statistically significant differences among the seed sources in yield and market grade of the tubers. On the average the virus tested seed yielded more than did the check seed. The virus tested seed by seed source interaction for yield was significant, therefore, a general statement about productivity of virus free seed is not justified, but each seed source must be considered separately. In three of the six paired comparisons the total yield of the check tubers was equal to or better than that of the virus tested seed, Table 6. The percentage of U.S. No. 1 tubers and the blackspot index for the virus tested seed was significantly lower than for the check seed.

The main effects of fertilizer were highly significant for a number of factors considered, but since none of the fertilizer interactions were significant the fertilizer effects will be shown later in this paper.

Table 5. Results of analysis of variance for the factors considered in the 1973 virus tested potato seed study.[1]

Source	dF	Total Yield	Yield # 1's	% # 1's	Specific Gravity	Black spot	Chip Color
Strata	2	***	N.S.	*	*	***	*
Seed Sources	5	*	***	***	N.S.	N.S.	N.S.
(error a)	10						
Virus vs Check	1	*	N.S.	***	N.S.	***	*
VF x Source	5	*	N.S.	N.S.	N.S.	N.S.	N.S.
(error b)	12						
Fertilizer	2	***	***	***	***	**	N.S.
F X S	10	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
F x VF	2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
F x S x VF	10	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
(error c)	48						
Total	107						

[1] N.S. = nonsignificant at 5% level; * = significant at 5% level; ** = significant at 1% level; *** = significant at .5% level.

The total yield data before and after adjustment for differences in seed piece size are shown in Table 6. The seed piece sizes for the paired comparisons are relatively uniform, but the differences among seed piece sizes for the sources of seed were considerably more variable. Equating all yields to a common seed piece size gives a better comparison for yield among the different seed sources and also makes the comparison between the 1972 and 1973 data a trifle more discriminating. Therefore, percentage differences were based on a 50 gram seed piece size.

Three of the six seed sources showed a yield advantage for the virus tested seed and three showed a yield advantage for check seed. The magnitude of the difference in favor of virus tested seed, however, was greater than for the check seed. When the analysis of variance included only seed sources 3, 4, 5, and 6, there were no differences significant at the 19:1 level. When Duncan's multiple range test was applied to all sources, only sources 1 and 2 were significantly different from

the rest. When the yields for the virus tested seed from seed sources 1 and 2 were compared with their adjacent random checks instead of their paired checks, the 29% and the 27% differences decreased to 7 and 16% respectively.

The adjusted yield of the virus (VF) seed from seed source 1 was 762 cwt/acre and that from seed source 6 was 608 cwt/acre. The difference was 154, a difference of 25%. The adjusted yield of the check seed from source 3 was 712 cwt/acre and that from seed source 1 was 588 cwt/acre. The difference was 124 cwt/acre, a difference of 21%.

That the virus tested seed and the check potato seed sources were actually different in virus content is evident from the serological tests performed on leaflets taken when the plants were about two feet tall, Table 7.

Table 6. 1973 total yield data before and after adjustment to a 50 gram seed piece size.

Source		Yield cwt/acre	Seed Size grams	Adjusted Yield cwt/acre	% Diff
1.	VF	769	56.5	762	
	CK	598	56.4	592	
	Diff	171	.1	170	29
2.	VF	748	54.5	744	
	CK	593	55.1	588	
	Diff	155	.6	156	27
3.	VF	700	58.3	692	
	CK	719	56.5	712	
	Diff	-19	1.8	-20	-3
4.	VF	683	55.9	677	
	CK	618	57.4	611	
	Diff	65	1.5	66	11
5.	VF	616	51.7	614	
	CK	634	54.9	629	
	Diff	-18	3.2	-15	-2
6.	VF	613	55.1	608	
	CK	644	54.1	640	
	Diff	-31	1.0	-32	-5

Table 7. Differences in the percentages of the leaflets infected with PVX and PVS among the sources of virus tested and among the sources of check tubers used in 1973.

Source	%PVS	%PVX
1. VF	7	2
CK	36	98
2. VF	2	0
CK	73	98
3. VF	0	0
CK	80	98
4. VF	7	0
CK	91	93
5. VF	0	2
CK	49	100
6. VF	2	0
CK	16	93
Mean VF	3	1
CK	58	97

The effect of fertilizer levels on the yield of potatoes grown from virus tested and check seed is shown in Table 8. The average difference in yield between the virus tested and the check seed was 9% in favor of the virus tested seed. It should be remembered, however, that VF x Source of seed interaction was significant and that in some instances there was no advantage in yield due to the virus tested seed. The highest yields were produced with the lowest rates of fertilizer applied. The differences in yield between the virus tested and check seed was greatest at the lowest fertilizer rate, but since the interaction was not significant no importance should be given to the difference.

Even though a surplus of fertilizer was applied, the serological tester identified the plot planted with virus infected seed in 100% of the cases.

Table 8. The effect of fertilizer levels on the yield of potatoes grown from virus tested and check seed in 1973.

	lb/acre 16-16-16			
	1250	1875	2500	Mean
Mean VF	754	679	619	684
Check	671	640	575	629
Difference	83	39	44	55
% Change	12	6	8	9

Discussion

When the results of 1972 and 1973 are considered together, there were 10 comparisons among virus tested and comparable check lots of seed potatoes. In 8 of the 10 comparisons the check seed from a regular seed certification program produced tuber yields equal to or better than comparable PVX and PVS tested seed. In these studies the influence of seed piece size on yield was minor. The findings lend support to those of Murphy (4) for Katahdin and Kennebec potatoes. The largest differences in yield were associated with seed sources both in 1972 and 1973. The percentage differences among the seed sources in 1973 were of the same order of magnitude as those reported by Ohms (5). The source differences were several times greater than those attributable to latent virus content. The range in productiveness found among the sources of virus tested and virus infected seed would make it relatively easy to find data to either support or negate the theory that virus tested seed is more productive than comparable PVX and PVS infected check tuber seed.

The mean yield after adjustment to a 50 gram seed piece size in 1972 was 908 cwt/acre. In 1973 it was 656 cwt/acre. The mean difference in yield between the two years was 252 cwt/acre which is 38% of the 1973 yield. Assuming that the vigor of the seed was about equal both years, this would indicate that soil, fertility and climatic differences are probably more important for the production of maximum yields than the latent virus content of the seed.

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