Know-how for Horticulture™

Virus testing of early generation certified seed potato crops in Western Australia

Mark Holland
Department of Agriculture
Western Australia

Project Number: PT01048

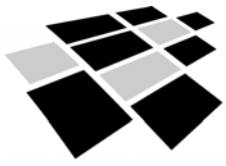
PT01048

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the potato industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of the WA Potato Producers Committee.

ISBN 0 7341 0723 4

Published and distributed by:
Horticultural Australia Ltd
Level 1
50 Carrington Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au



Horticulture Australia

Horticulture Australia Project PT01048

(March 2003)

FINAL REPORT

Virus testing of early generation seed potato crops in Western Australia

Mark Holland

Department of Agriculture

Western Australia

PT01048

Mark Holland
Department of Agriculture
Baron-Hay Court
South Perth WA 6151
Tel (08) 9368 3721 Fax (08) 9474 2658 EMAIL mbholland@agric.wa.gov.au

Purpose of the report:

This report illuminates the virus status of Western Australian certified and registered seed potato crops. Generation 2 sown crops were tested during the 2001/02 season to assist seedgrowers to identify G3 seed lots infected by Western Australia's four most serious seed borne virus diseases. Tomato Spotted Wilt Virus (TSWV), Potato Virus S (PVS), Potato Virus X (PVX) and Potato Leaf Roll Virus (PLRV) were tested. The results of the testing and recommendations for future of testing seed potato crops in WA are provided.

Funding

Funding for this project was provided by:

- Potato Producers Committee of the Western Australian Agricultural Produce Commission;
- Horticulture Australia Limited; and
- Department of Agriculture Western Australia.

.

Agricultural Produce Commission

Horticulture Australia

Department of Agriculture
Government of Western Australia

29 October 2002

CONTENTS

Media summary

Maintaining low virus levels in seed potatoes presents a serious challenge under Western Australian conditions. In general virus levels have been controlled within the seed schemes, however, serious outbreaks have occurred and are an area of a concern for the domestic industry and pose a threat to the successful supply of seed potatoes to emerging export markets.

Seventeen generation two sown seed potato crops were sampled and tested for four major seed borne viruses, Potato Leaf Roll Virus (PLRV), Tomato Spotted Wilt Virus (TSWV), Potato Virus S (PVS) and Potato Virus X (PVX). This survey illuminates the virus status of Western Australia's certified and registered seed potato schemes. These schemes became operational in 1997.

A statistical package was produced to identify crops exceeding critical values for a range of sample sizes and critical values.

An average of 478 plants were tested per grower. Results of the survey show 307 positive results from 8137 plants tested. No virus detected in nine of the growers crops. The most prevalent virus detected was PVX (275 infected plants from one grower), followed by PVS (23 infected plants from three growers), PLRV (eight infected plants from six growers) and the least prevalent TSWV (one infected plant from one grower).

Potato Leafroll Virus was found to be under control in both seed schemes. However the virus was detected at six of the seventeen growers tested, showing a presence of the virus in many seed crops and underlining the need for growers and seed certification inspectors to remain vigilant.

The latent viruses Potato Virus X and Potato Virus S are practically invisible in the summer production period. Both viruses were found to be almost non existent in the certified seed scheme and presence in the registered seed scheme showed a vast improvement on results of a 1987/88 survey (Wilson & Jones, 1989) of approved seed from the Albany swamps. That survey showed PVX infecting 73% of plants and PVS infecting 55%.

Only one plant was infected with Tomato Spotted Wilt Virus.

The results were used by seedgrowers to identify outbreaks of viruses in their production pipeline. Crops exceeding critical levels of virus were rejected from the seed scheme.

This survey shows that the new certified seed scheme is successfully controlling all major viruses found in Western Australia. The survey also found that the registered seed scheme was controlling infection with PLRV and TSWV and that the incidence of PVS and PVX has improved significantly.

The introduction of standards to enable rejection of crops excessively infected with PVS or PVX, combined with a continuation of testing to identify outbreaks could see these viruses reduced eliminated in the near future.

Technical summary

Maintaining low virus levels in seed potatoes presents a serious challenge under Western Australian conditions. In general virus levels have been controlled within the seed schemes, however, serious outbreaks have occurred and are an area of a concern for the domestic

industry and pose a threat to the successful supply of seed potatoes to emerging export markets.

Many virus diseases affect potato crops by reducing yield and adversely affecting the quality of tubers. The presence of seed borne viruses are of significant concern to the potato industry. It is important that seed potato crops have no or minimal levels of seed borne viruses to ensure future crops perform to their potential. However, visual detection of viruses is often difficult as symptoms can take weeks to display or may not show at all.

The latent viruses Potato Virus X and Potato Virus S are practically invisible in the summer production period. There is a growing trend for export markets to subject seed lots to mandatory testing for viruses. Several seed lots were rejected for export in 2002 after detection of PVS and PVX.

PLRV and TSWV current season infections take a number of weeks to show symptoms of infection and in some varieties no symptoms become evident. Even seed borne infections can take several weeks to display symptoms in some varieties.

In 1997 two new seed schemes, a certified seed scheme and a registered seed scheme, were introduced by the Western Australian seed potato industry. The certified seed scheme was created primarily to facilitate exports and the registered seed scheme upgraded the pre existing approved seed scheme.

The approved seed schemes was clonally based with an unlimited number of generations, no rotation, limited isolation and labelling requirements. A 1987/88 survey of approved seed from the Albany swamps showed PVX infecting 73% and PVS infecting 55% of plants (Wilson & Jones, 1989). Lower levels were noted in crops recently sown with pathogen tested source material.

This survey illuminates the virus status of Western Australia's new certified and registered seed potato schemes.

A total of 500 leaf samples were taken from generation two sown seed crops close to senescence. The newest fully developed leaves were chosen. The number of samples taken per plot was proportional to the total area sown to generation two crops.

The origin of samples was recorded to pinpoint problem plots. Samples were couriered in cooled esky's to ensure they arrived at the laboratory in good order, however, the summer temperatures, independent transport systems and advanced age of the leaves combined to render 7% of the samples unsuitable to test.

Samples were tested by in the Department of Agriculture's virology laboratory under the supervision of Dr Roger Jones. PLRV was detected by Tissue Blotting Immunoassay (Tissue Print) (Hsu & Lawson, 1991; Lin, et. al., 1990). The tissue print method allows the number of infected samples to be directly identified. The other viruses were tested by Enzyme-linked Iimmunosorbent Assay (ELISA) in groupings of 10 leaves. The number of infected samples identified by the ELISA method was estimated using a formula of Gibbs & Gower (1960). Results of the testing were sent to seed growers and the Seed Certification Authority, usually within a week of sampling.

Crops exceeding pre agreed critical limits were rejected from the scheme. If results were cause for concern, but below the critical limit, the Seed Certification Authority contacted the grower to discuss options for management or eradication of the problem. In this situation any action was the responsibility of the seedgrower. A statistical package was produced to identify crops exceeding critical values for a range of sample sizes and critical values.

Potato Leafroll Virus was found to be under control in both seed schemes. However, the virus was detected at six of the seventeen growers tested, showing the virus has a presence in many seed crops and underlining the need for growers and seed certification inspectors to remain vigilant for vectors and resulting outbreaks of the disease.

The latent viruses Potato Virus X and Potato Virus S are practically invisible in the summer production period. Both viruses were found to be under control in the certified seed scheme. The infection rate of registered seed crops was well below expectations as a 1987/88 survey of approved seed from the Albany swamps showed PVX infecting 73% of plants and PVS infecting 55% (Wilson & Jones, 1989).

Only one plant was detected with Tomato Spotted Wilt Virus.

The results were used by seedgrowers to identify outbreaks of viruses in their production pipeline.

This survey shows that the new certified seed scheme is successfully controlling all major viruses found in Western Australia. The survey also found that the registered seed scheme was controlling infection with PLRV and TSWV and that the incidence of PVS and PVX has improved significantly. Introduction of standards to enable rejection of excessive infected crops combined with a continuation of testing for PVS and PVX could see these viruses eradicated from the registered seed scheme in the near future.

The testing program was reviewed at grower meetings at the end of the season and by the Western Australian Seed Advisory Committee. Both groups endorsed the value, focus and continuation of the program.

Introduction

Maintaining low virus levels in seed potatoes presents a serious challenge under Western Australian conditions. In general virus levels have been controlled within the seed schemes, however, serious outbreaks have occurred and are an area of a concern for the domestic industry and pose a threat to the successful supply of seed potatoes to emerging export markets.

Many virus diseases affect potato crops by reducing yield and adversely affecting the quality of tubers. The presence of seed borne viruses are of significant concern to the potato industry. It is important that seed potato crops have no or minimal levels of seed borne viruses to ensure future crops perform to their potential.

The most serious seed borne virus diseases affecting Western Australian crops are Potato Leafroll Virus (PLRV), Tomato Spotted Wilt Virus (TSWV) and Potato Virus S (PVS) and Potato Virus X (PVX). The presence of these viruses in Western Australian seed crops has caused serious losses in the past.

In 1997 two new seed schemes, the certified and registered seed scheme, were introduced by the Western Australian seed potato industry. The certified seed scheme was created primarily to facilitate exports and the registered seed scheme upgraded the pre existing approved seed scheme.

The approved seed schemes was clonal based with an unlimited number of generations, no rotation, limited isolation and labelling requirements. A previous survey of viruses (Wilson & Jones, 1989) found the approved seed crops heavily infected with PVS and PVX. Both PVS and PVX are very difficult to identify visually in the summer growing period.

Both new schemes feature Pathogen Tested source material and a limited number of generations. The registered seed scheme differs from the certified seed scheme in many ways including reduced isolation between generations and rotation requirements.

This survey illuminates the virus status of Western Australia's relatively new certified and registered seed potato schemes. The assessment was made by testing seed crops late in their third field generation during the 2001/2002 season.

Materials and methods

The survey was managed by the Western Australian Department of Agriculture. Crop inspection staff of the Department collected leaf samples while observing a crop hygiene protocol. Rubber boots and plastic trousers were disinfected at entry to and exit from each site. The crops were located in Esperance, Albany, Rosa Brook, Manjimup and Scott River. A total of 500 leaf samples were taken from generation two sown seed crops close to senescence. The newest fully developed leaves were chosen. The number of samples taken per plot was proportional to the total area sown with generation two crops.

The origin of samples was recorded to pinpoint problem plots. Samples were couriered in cooled esky's to ensure they arrived at the laboratory in good order, however, the summer temperatures, independent transport systems and advanced age of the leaves combined to render 7% of the samples unsuitable to test.

Samples were tested by in the Department of Agriculture's virology laboratory under the supervision of Dr Roger Jones. PLRV was detected by a Tissue Print method. The Tissue Print method allows the number of infected samples to be directly identified. Other viruses were tested by Enzyme-linked immunosorbent assay (ELISA) in groupings of 10 leaves. The number of infected samples identified by the ELISA method was estimated using a formula of Gibbs and Gower (1960). Results of the testing were sent to seed growers and the Seed Certification Authority, usually within a week of sampling.

In Western Australia the Seed Certification Authority consults with industry through an industry consultative committee (The Western Australian Seed Advisory Committee). The committee approved use of the test results by the Seed Certification Authority. Seedgrowers were advised of actions that the Authority would take at various levels of infection. Any crops exceeding the critical limits were rejected from the Seed Schemes. A statistical package was developed by Ms Jane Speijers, biometrican, WA Department of Agriculture, to assist the authority to determine if a result exceeded any critical limit for a range of sample sizes, at the 95% level of confidence. This confidence limit is in concert with those used in OECD Seed Schemes.

If results were cause for concern, but below the critical limits, the Seed Certification Authority contacted the grower to discuss options for management or eradication of the problem. In this situation any action was the responsibility of the seedgrower.

Results

Test Results

Overall

Results of the survey show 307 positive results from 8137 plants tested. No virus detected in nine of the growers crops.

The survey showed no virus was detected in nine of the seventeen growers tested. Approximately 307 positive results were returned from 8137 plants tested. An average of 478 plants were tested per grower at an infection rate of 3.92%. It is not known if plants were infected with more than one virus. Of the infected plants 292 positive results came from one plot from grower 12. Removing grower 12 from the equation gives an infection rate for all viruses of 0.20%.

The most prevalent virus detected was PVX (275 infected plants from one grower), followed by PVS (23 infected plants from three growers), PLRV (eight infected plants from six growers) and least prevalent TSWV (one infected plant from one grower).

303 infected plants were detected in the registered seed scheme and 5 infected plants detected in the certified seed scheme. The schemes contributed roughly equal numbers of plants to the survey.

Table 1 Summary of Virus Test Results on Leaf Samples

Grower	Seed scheme	Number of samples tested	Number of samples infected with PLRV	Number of samples infected with TSWV	Number of samples infected with PVS	Number of samples infected with PVX
Grower 1	Registered	430	2	0	0	0
Grower 2	Registered	500	0	0	0	0
Grower 3	Certified	500	1	0	0	0
Grower 4	Registered	379	0	0	7	0
Grower 5	Registered	200	0	0	0	0
Grower 6	Certified	782	1	1	0	0
Grower 7	Certified	480	1	0	0	0
Grower 8	Certified	675	0	0	1	0
Grower 9	Registered	496	1	0	0	0
Grower 10	Certified	220	0	0	0	0
Grower 11	Certified	615	0	0	0	0
Grower 12	Registered	500	2	0	15	275
Grower 13	Certified	500	0	0	0	0
Grower 14	Certified	550	0	0	0	0
Grower 15	Registered	500	0	0	0	0
Grower 16	Registered	500	0	0	0	0
Grower 17	Certified	310	0	0	0	0
Total		**8137**	**8**	**1**	**23**	**275**
Percentage of samples infected			0.10	0.01	0.28	3.38

Statistical Package

The aim of the package is to calculate the number of diseased potatoes in samples of varying size that indicate that the level of disease in the population is greater than some critical value. Assuming that the proportion of diseased potatoes in a population is *p* and that the number of diseased potatoes in a sample of *n* potatoes from the population is *r*, then

$$P\{r > R\} = 1 - \sum_{i=0}^{R} {}^{n}C_i p^i (1-p)^{n-i} \qquad \text{where } {}^{n}C_i = \frac{n!}{(n-i)!i!}$$

We choose *R* so that for *p* =*P*, the critical value, $P\{r > R\} < 0.05$, and $P\{r > R-1\} > 0.05$. If R or more diseased plants occur in a sample then we can say that this is very improbable and therefore the proportion of plants in the population is greater than *P*.

Values of R for a range of sample sizes, n, and critical proportions, P, are shown in appendix 2.

An example of how the package is used:

If we take a sample of size 100 leaves, 6 or more diseased potatoes in the sample would indicate that the proportion of diseased potatoes in the population is greater than 2% (p<0.05). Note that there is always a considerable chance of seeing a higher proportion of diseased potatoes in the sample than there is in the population, so the proportion of diseased potatoes in the sample must be quite a bit higher than 2% to be able to conclude that the proportion of diseased potatoes in the population is greater than 2%.

Table 2 Rejection Points for a range of sample sizes and critical values.

	Critical values										
Sample Size	P= 0.1%	P= 0.2%	P= 0.3%	P= 0.4%	P= 0.5%	P= 1%	P= 1.5%	P= 2%	P= 3%	P= 4%	P= 5%
20	1	1	2	2	2	2	2	3	3	3	4
40	1	2	2	2	2	3	3	3	4	5	5
60	2	2	2	2	2	3	4	4	5	6	7
80	2	2	2	2	3	3	4	5	6	7	8
100	2	2	2	3	3	4	5	6	7	8	10
200	2	3	3	3	4	6	7	8	11	14	16
300	2	3	4	4	5	7	9	11	15	19	22
400	3	3	4	5	6	9	11	14	19	24	28
500	3	4	5	6	6	10	13	16	23	28	34
600	3	4	5	6	7	11	15	19	26	33	40
800	3	5	6	7	9	14	19	24	33	42	na
1000	4	6	7	9	10	16	23	29	40	*na*	*na*
2000	6	9	11	14	16	29	40	*na*	*na*	*na*	*na*

na - not available due to roundoff errors in calculations

Discussion

Overall

This project sought to establish the virus status of generation two (G2) sown seed crops and to establish the advantages of identifying emerging infection in seed grower programs. The survey also sought to assist the seed certification authority to evaluate the effectiveness of the two schemes to control viruses.

The results showed that viruses were largely under control across the seed schemes in 2001/2002. The percentage of plants infected with all viruses was 3.77%. However infection by PVX of one grower accounted for 3.38% of the plants infected. Discounting that growers PVX results the percentage of plants infected with the four viruses was 0.39%. This laboratory measured level compares favourably with the visually determined standard for generation two seed, which is 0.25%.

The registered seed scheme isolation requirements between generations is insufficient to prevent plants touching and spreading PVS and PVX into clean generations. Rectification of this problem could result in improved results.

Staggered times of sowing demanded an estimation of the number of samples taken at any particular visit and caused some inaccuracy in the total number of samples taken. In addition, the perishability of the aged leaves, the high temperatures and inability to control the transportation system also resulted in fewer leaves than intended reaching the laboratory in good order.

Potato Leafroll Virus

PLRV can be seed borne or introduced to and spread within crops by aphids. Identification of plants infected with PLRV within a growing season (current season infection) is particularly difficult and often beyond the ability of seed growers and seed certification inspectors. Plants growing from infected seed pieces are usually easier to detect but can take several weeks to display symptoms.

Overall the laboratory tested level of 0.1% of plants infected with PLRV compares favourably with the visual detection standard of 0.25% total for all virus in generation two sown crops . However, PLRV infected plants were detected in six of the seventeen growers indicating a source of infection will exist in many of next seasons crops. Research has shown potato plants are most susceptible to infection with PLRV early in the life of the crop (Loebenstein, 2001). Growers will need to control early aphid infestations and ensure thorough roguing occurs at the earliest expression of symptoms to guard against serious outbreaks of the disease next season.

Tomato Spotted Wilt Virus

TSWV is spread by thrips. Identification of plants infected with TSWV is usually possible in the field. In recent seasons infections have been identified by seed certification inspectors and resulted in crops being rejected from the seed schemes or downgraded.

TSWV was only detected in one plant in the survey and appears to be under control in 2001/2002. Growers have been warned that TSWV has a large host range and that thrips in their crop may be introducing infection.

Potato Virus S and Potato Virus X

PVS and PVX are 'contact viruses' transmitted from infected to healthy plants by such actions as the movement of personnel and equipment through a crop or by the cutting of tubers into seed pieces. PVS is also spread by aphids. Identification of infected plants is very difficult, particularly in summer crops. The virus can spread quickly from an infected seed lot or crop when hygiene is inadequate.

Testing of certified seed growers plants detected only one plant infected with PVS or PVX. The certified seed scheme rules and the growers practices appear to be maintaining the freedom from PVS and PVX.

PVS and PVX infection was almost entirely confined to crops of the registered seed scheme. The forerunner to the registered seed scheme, the approved seed scheme, was heavily infected with PVS (55% of plants infected) and PVX (73% of plants infected) (Jones & Wilson, 1989). The industry phased out the Approved Seed Scheme in 2000. This survey found the percentage of plants infected with PVS has declined to 0.28% and for PVX it has declined to 3.38%. Only two registered seed growers crops were found to be infected with PVS and PVX, although one crop was heavily infected. The substantial reduction in infection is though to be a function of:

- Exclusive use of Pathogen Tested source seed;
- Limiting the number of generations seed can be propagated;
- More widespread knowledge of the methods of disease transmission among seed growers;
- Improved hygienic practices in seed cutting operations;
- Improved hygienic practices when staff and machinery move through the generations.

The program provides seed potato growers an opportunity to identify any emerging viral problems with and ensure remedial action is put in place. Remedial action effected as a result of this testing includes:

- Disposal of the crop from the seed growers program as either wares, processing or seed depending on the severity of the infection level;
- Extra attention to roguing the following crop;
- Additional insecticide applications to the following crop;
- Extra attention to hygiene and isolation of the following crop;
- Extra attention to hygiene during seed cutting operations.

Increasingly export markets are demanding laboratory testing of seed prior to import and placing restrictions on the level of virus permitted. The Sri Lankan market currently has a

zero tolerance on PVX and a limit of 6% total for PVS, PLRV and TSWV. Action to control of the infections identified in this survey is critical to retaining this market considering seed is usually exported as fourth generation seed.

Confidence in the test procedure is increasing after early scepticism by seedgrowers. The experience of seeing test results being reflected in the following years crop is improving acceptance of the technology. In end of season reviews of the testing program, seedgrowers commended the testing program as providing timely and relevant information which enabled them to take appropriate action to identify and resolve threats to the production of healthy seed potatoes.

The conduct of this survey has resulted in growers of seed potatoes and their customers having more confidence that seed crops will have minimal levels of virus infected seeds.

The Western Australian Seed Advisory Committee has recommended continuation of the program.

Technology Transfer

This testing program was devised for the benefit of WA seed potato growers and the wider potato industry. Seedgrowers and the Seed Certification Authority were provided with results of the testing on their seed crops within a week of sampling. The seed potato industry and the WA Seed Advisory Committee were provided summaries of the testing. For legal reasons it is essential that growers confidentiality is preserved.

The procedures employed in the conduct of this survey were found to be adequate and no recommendations regarding changes to the program were suggested by growers or the Seed Advisory Committee.

Recommendations

1. The Registered Seed Scheme has significantly reduced the level of PVX and PVS present in the seed scheme. Considering the growing importance of these viruses in export markets it is recommended registered seed growers consider mounting efforts to eradicate these viruses from the scheme. Possible measures include:

    - Adopting the certified seed scheme inter generational isolation requirements;
    - Mandatory rejection of crops showing high levels of PVS and PVX in future surveys.
    - Growers only import seed lots tested clear of these viruses.

2. Consideration be given to expanding the virus tested to include Potato Virus Y (PVY). PVY has not been reliably detected by serological methods in Western Australia. However, it is a common and serious disease of potatoes found in most growing areas of the world. A severe necrotic strain of PVY, PVY^{NT} , has become common in North America and Europe and recently appeared in New Zealand. The Western Australian industry could further enhance its competitive advantage as a clean source of seed potatoes if it can prove area freedom of PVY and/or PVY^{NT}. Without testing for the disease by scientific means Western Australia is prevented from claiming area freedom under the World Trade Organisation rules for sanitary and phytosanitary certificates. Extending the testing program to include PVY and PVY^{NT} would constitute a first step in

proving area freedom of these diseases. It is recommended the virus testing program be continued and expanded to include PVY.

3. It is recommended that the Seed Potatoes Australia Group consider implementing virus indexing to the National Standard for the Certification of Seed Potatoes to aid in the production of low level virus infected seed.

Bibliography

Fletcher, J.D., Dunnock, J., Lister, R.A. & Butler, R.C. (2002), Proceedings 8th International Plant Virus epidemiology symposium, Aschersleben, Germany, p 15.

Gibbs A. J. & Gower, J. C. (1960), The use of multiple transfer method in plant virus transmission studies – some statistical points arising from the analysis of results. *Annals of Applied Biology*, vol 48, pp. 75-83.

Hsu, H.T. & Lawson, R.H. (1991), Direct tissue blotting for detection of tomato spotted wilt virus in Impatients., *Plant Disease*, vol 75, pp. 292-295.

Lin, N.S., Hsu, Y.H. & Hsu, H.T. (1990), Immunological detection of plant viruses and a mycoplassmalike organism by direct tissue blotting on nitrocellulose membranes., *Phytopathology,* vol 80, 824-828.

Loebenstein, G. (2001), Virus and virus-like diseases of potatoes and production of seed potatoes., *Kluwer Academic Publishers*, Dordrecht, 2001.

Wilson, C. R. & Jones, R.A. C. (1989), Virus content of seed potato stocks produced in a unique seed potato production scheme, *Annals of Applied Biology*, vol 116, pp. 103-109.

Wilson, C. R. & Jones, R.A. C. (1993), Evaluation of resistance to potato leafroll virus in selected cultivars under field conditions, *Australian Journal of Experimental Agriculture,* vol 33, pp. 83-90.

Appendices

Grower	Variety	Number of samples tested	Number of samples infected with PLRV	Number of samples infected with TSWV	Number of samples infected with PVS	Number of samples infected with PVX
Grower 1	Shine	150	0	0	0	0
Grower 1	Ruby Lou	160	2	0	0	0
Grower 1	Atlantic	50	0	0	0	0
Grower 1	Russet Burbank	50	0	0	0	0
Grower 1	90-2-6	20	0	0	0	0
Grower 2	Atlantic	250	0	0	0	0
Grower 2	Ruby Lou	250	0	0	0	0
Grower 3	Atlantic	100	0	0	0	0
Grower 3	Spunta	100	0	0	0	0
Grower 3	Delaware	100	0	0	0	0
Grower 3	Mondial	100	0	0	0	0
Grower 3	Carlingford	100	1	0	0	0
Grower 4	Russet Burbank	26	0	0	5	0
Grower 4	Atlantic	9	0	0	1	0
Grower 4	Delaware	55	0	0	0	0
Grower 4	Mondial	55	0	0	0	0
Grower 4	Bremer	55	0	0	0	0
Grower 4	Royal Blue	55	0	0	1	0
Grower 4	Nadine	55	0	0	0	0
Grower 4	Nooksack	55	0	0	0	0
Grower 4	Ruby Lou	14	0	0	0	0
Grower 5	Delaware	50	0	0	0	0
Grower 5	Kennebec	50	0	0	0	0
Grower 5	MacRusset	50	0	0	0	0
Grower 5	Nadine	50	0	0	0	0
Grower 6	Shine	50	1	0	0	0
Grower 6	Ruby Lou	53	0	0	0	0

Grower 6	Sebago	58	0	0	0	0
Grower 6	Ruby Lou	50	0	0	0	0
Grower 6	Desiree	55	0	0	0	0
Grower 6	Atlantic	56	0	0	0	0
Grower 6	Desiree	50	0	0	0	0
Grower 6	Ruby Lou	130	0	0	0	0
Grower 6	Desiree	90	0	0	0	0
Grower 6	Shine	80	0	0	0	0
Grower 6	Atlantic	110	0	1	0	0
Grower 7	Ruby Lou	480	1	0	0	0
Grower 8	Ruby Lou	65	0	0	0	0
Grower 8	Mondial	65	0	0	0	0
Grower 8	Mondial	65	0	0	0	0
Grower 8	Delaware	65	0	0	0	0
Grower 8	Royal Blue	65	0	0	0	0
Grower 8	Nadine	65	0	0	0	0
Grower 8	Eureka	45	0	0	0	0
Grower 8	Nadine	40	0	0	0	0
Grower 8	Royal Blue	40	0	0	1	0
Grower 8	Mondial	40	0	0	0	0
Grower 8	Ruby Lou	40	0	0	0	0
Grower 8	Delaware	40	0	0	0	0
Grower 8	Nadine	40	0	0	0	0
Grower 9	Ruby Lou	62	0	0	0	0
Grower 9	Nadine	62	0	0	0	0
Grower 9	Redgem	62	1	0	0	0
Grower 9	Nadine	62	0	0	0	0
Grower 9	Argos	62	0	0	0	0
Grower 9	Harmony	62	0	0	0	0
Grower 9	Valour	62	0	0	0	0
Grower 9	Kestral	62	0	0	0	0
Grower 10	Desiree	220	0	0	0	0

Grower 11	Atlantic	30	0	0	0	0
Grower 11	Delaware	30	0	0	0	0
Grower 11	Nadine	100	0	0	0	0
Grower 11	Russet Burbank	35	0	0	0	0
Grower 11	Mondial	35	0	0	0	0
Grower 11	Ganola	35	0	0	0	0
Grower 11	Delaware	35	0	0	0	0
Grower 11	Atlantic	35	0	0	0	0
Grower 11	Desiree	35	0	0	0	0
Grower 11	Eben	35	0	0	0	0
Grower 11	KT3	35	0	0	0	0
Grower 11	FL 1867	35	0	0	0	0
Grower 11	Granola	35	0	0	0	0
Grower 11	VC51.6	35	0	0	0	0
Grower 11	PO3	35	0	0	0	0
Grower 11	Granola	35	0	0	0	0
Grower 12	Delaware	500	2	0	15	275
Grower 13	Red Pontiac	100	0	0	0	0
Grower 13	Coliban	100	0	0	0	0
Grower 13	Sebago	100	0	0	0	0
Grower 13	Clone	100	0	0	0	0
Grower 13	Russet Burbank	100	0	0	0	0
Grower 14	Atlantic	250	0	0	0	0
Grower 14	Atlantic	300	0	0	0	0
Grower 15	Delaware	100	0	0	0	0
Grower 15	Nadine	100	0	0	0	0
Grower 15	Atlantic	100	0	0	0	0
Grower 15	Dawmor	100	0	0	0	0
Grower 15	Eureka	100	0	0	0	0
Grower 16	Ruby Lou	125	0	0	0	0
Grower 16	Eureka	125	0	0	0	0
Grower 16	Delaware	125	0	0	0	0

Grower 16	Royal Blue	125	0	0	0	0
Grower 17	Desiree	310	0	0	0	0
		8137	8	1	23	275
Percentage of plots positive			0.10%	0.01%	0.28%	3.38%