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**Minimising virus
infection in early
generaton seed
potato crops in
Western Australia**

Mark Holland
Department of Agriculture
Western Australia

Project Number: PT02047

PT02047

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**Horticulture Australia Project PT02047
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FINAL REPORT

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

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PT02047

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Purpose of the report:

This report illuminates the virus status of Western Australian certified and registered seed potatoes. Generation 2 sown crops were tested during the 2002/03 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. In addition, samples were tested for the presence of Potato Virus Y (PVY), a serious virus disease of potatoes that appeared not to be established in Western Australia. The results of the testing and recommendations for future of testing seed potato crops in WA are provided.

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first obtaining specific, independent professional advice in respect of the matters set out in this publication.

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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. They are an area of concern for the domestic industry and pose a threat to the successful supply of seed potatoes to emerging export markets.

This survey illuminates the virus status of Western Australia's certified and registered seed potato schemes. These schemes became operational in 1997. Twenty one generation 2 sown seed potato crops were sampled and tested for five major seed-borne viruses, Potato Leaf Roll Virus (PLRV), Potato Virus Y (PVY), Tomato Spotted Wilt Virus (TSWV), Potato Virus S (PVS) and Potato Virus X (PVX). In addition to viruses tested in previous testing programs Potato Virus Y was included to help confirm the presence or absence of the virus in Western Australia.

An average of 497 plants were tested per grower. Results of the survey show 139 positive results for all viruses from the 10450 plants tested. No virus was detected in seven growers crops. The most prevalent viruses detected were PLRV and TSWV (66 and 64 infected plants respectively), followed by PVS (five infected plants from three growers) and PVX (four infected plants from one grower). PVY was not detected.

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

PVS and PVX symptoms are practically invisible in the summer production period. Both viruses were found to be almost non existent in both certified and registered seed schemes. The presence of PVX and PVS 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%.

Three serious outbreaks of virus were detected. Two of PLRV and one of TSWV. The results were used by seedgrowers to identify the lots most at risk and determine appropriate action. Crops exceeding critical levels of virus were rejected from the seed scheme therefore preventing serious losses in larger future generation 3 (G3) sown seed crops.

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 results of the PVS and PVX testing will be used to propose the introduction of standards to the Registered Seed to enable rejection of crops identified with excessive levels of plants infected with PVS or PVX. Continued testing to identify disease outbreaks could see these viruses almost eliminated from the Registered Seed Scheme in the near future. The methods used so effectively in Western Australia are being studied by seed schemes in all states through the operations of the Seed Potatoes Australia Group (SPAG) and in particular in Tasmania where a survey has shown seed to be seriously infected.

The results of the PVY testing were used in consideration by the Department when determining to undertake an eradication campaign when PVY was subsequently detected in breeding plots.

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 continue to occur. They are an area of 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 is 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 generations of commercial crops can 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.

PVS and PVX symptoms 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 generation four 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 scheme 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).

The current survey illuminates the virus status of Western Australia's new certified and registered seed potato schemes. A total of 500 leaf samples were taken per site from generation 2 sown seed crops close to senescence. The newest fully developed leaves were randomly sampled. 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 approximately 5% of the samples unsuitable to test.

Samples were tested 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 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 & 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.

PLRV was found to be under control in both seed schemes. However, it was detected at eight of the twenty one growers properties 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 aphid vectors and resulting outbreaks of the disease.

PVS and PVX symptoms are practically invisible in the summer production period. Both viruses were found to be under control in the certified seed scheme in 2003. 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 two properties recorded TSWV, one serious infection was discovered and addressed. No PVY whatsoever was detected in the survey.

The results were used by seedgrowers to identify outbreaks of viruses in their production pipeline, determine their level of risk and consider approaches to the problem. Solutions included heavy roguing, insecticide application and further testing in next years crop, selling the seed accompanied by test results or disposing of the seed into processing or ware markets.

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. PVY was not detected and considered absent from WA.

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

Many virus diseases affect potato crops, reducing yield and/or adversely affecting the quality of tubers. The presence of seed-borne viruses is of significant concern in potato seed. It is important that seed potato crops have no or minimal levels of seed-borne viruses to enable future commercial crops to perform to their potential.

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 that concern the domestic industry and pose a threat to emerging export markets.

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

PVY had not been 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^{NTN}, 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^{NTN}. Without testing for the disease by scientific means Western Australia is prevented from claiming area freedom under the World Trade Organisation sanitary and phytosanitary rules. Extending the testing program to include PVY and PVY^{NTN} will constitute a first step in proving area freedom. Unfortunately an outbreak of the common PVY strain, originating from infected seed distributed from the Breeding Program, occurred shortly after the conduct of this project. This outbreak is subject to eradication.

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 to upgrade the pre existing approved seed scheme.

The approved seed scheme 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 in the 80's. Both PVS and PVX are very difficult to identify visually in the summer growing period. PLRV but not PVY were also found. Periodically, severe outbreaks of PLRV occurred under the approved scheme.

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, rotation, labelling requirements and tolerance of PVX and PVS.

This project evaluates the success of the schemes to control the virus diseases listed above. The assessment was made by testing seed crops late in their third field generation during the 2002/2003 season. It also proves the value of testing as a risk management tool for seed producers.

Materials and methods

The survey was managed by the Western Australian Department of Agriculture. Crop inspection staff of the Department's seed certification service collected leaf samples while observing a crop hygiene protocol. Personnel were disinfected at entry to and exit from each site. The crops were located in Esperance, Albany, Rosa Brook, Manjimup and Scott River. For each property 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 5% of the samples unsuitable to test.

Samples were tested 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. The 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 & 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, biometrician, 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 139 positive results for virus infection from the 10450 plants tested. No virus was detected in seven growers properties. An average of 497 plants were tested per grower at an infection rate of 1.3%. It is not known if any plants were infected with more than one virus. The most prevalent viruses detected were PLRV and TSWV (66 and 64 infected plants respectively), followed by PVS (five infected plants from three growers) and PVX (four infected plants from one grower). No PVY was detected.

Similar virus levels were identified in both schemes.

Table 1 Summary of Virus Test Results on Leaf Samples

Grower	Variety	No Samples	Potato Leaf Roll Virus	Tomato Spotted Wilt Virus	Potato Virus S	Potato Virus X	Potato Virus Y
Grower 6	Certified	625	0	0	0	0	
Grower 7	Certified	800	0	62	0	0	0
Grower 8	Certified	510	8	0	0	0	0
Grower 9	Certified	300	0	2	0	0	0
Grower 10	Certified	500	0	0	0	0	0
Grower 11	Certified	880	24	0	0	4	0
Grower 12	Certified	500	0	0	0	0	0
Grower 15	Certified	510	0	0	0	0	0

Grower 17 Certified	430	0	0	0	0	0
Grower 14 Certified	750	1	0	0	0	0
Grower 16 Cert and Reg	500		0	0	0	
Grower 5 Cert and Reg	510	1	0	0	0	0
Grower 1 Registered	280	2	0	0	0	0
Grower 2 Registered	540	0	0	0	0	0
Grower 3 Registered	400	0	0	0	0	0
Grower 18 Registered	500	3	0	3	0	0
Grower 4 Registered	645	0	0	2	0	0
Grower 13 Registered	500	25	0	0	0	0
Grower 19 Registered	200	0	0	0	0	0
Grower 20 Registered	220	0	0	0	0	0
Grower 21 Registered	350	2	0	0	0	0
Certified Seed Total Plants Testing Positive	5805	33	64	0	4	0
Registered Seed Total Plants Testing Positive	3635	32	0	5	0	0
All Growers Total Plants Testing Positive	10450	66	64	5	4	0
Certified Seed Percentage of Plants Testing Positive		0.57	1.10	0.00	0.07	0.00
Registered Seed Percentage of Plants Testing Positive		0.88	0.00	0.14	0.00	0.00
All Growers Percentage of Plants Testing Positive		0.66	0.61	0.05	0.04	0

Discussion

Overall

This project sought to establish the virus status of generation 2 (G2) sown seed crops and to demonstrate 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 2002/2003. The percentage of plants infected with all viruses was 1.3%. Compared to last year this represented an increase in PLRV and TSWV infection rates and a decline in PVX from 3.4% to 0.04%. Overall 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. This survey showed very low levels of PVS and PVS in the seed schemes.

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 is both seed-borne and 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 visually but can take several weeks to display symptoms.

Overall the laboratory tested level of 0.6% of plants infected with PLRV compares with the visual detection standard of 0.25% total for all virus in generation two sown crops. Two growers sites contributed the bulk of the infected plants. However, PLRV infected plants were detected in seven of the twenty one 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 and weeds are the principle virus reservoir. Identification of plants infected with TSWV is 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 on one property in the survey where it was at significant levels. Some crops there were rejected from the scheme as a result of the infection levels. Growers have been warned that TSWV has a large host range and that thrips in their crop may be introducing infection from nearby weed sources.

Potato Virus Y

PVY is a common and serious disease of potatoes that is present in most seed growing areas of the world. It is spread by aphids. Identification of infected plants is variety specific. Some varieties show obvious symptoms, particularly plants that grow from infected tubers, while others show few symptoms. Identification in crops after row closure is problematical.

The survey showed no presence of PVY in either seed scheme. However, an outbreak of PVY was detected among lines distributed under the National Breeding Program shortly after this program was completed. Some of the infected lots were located on seed growers properties. The data from this project was used by the Department of Agriculture in deciding to attempt an eradication program. As the disease was not widespread eradication is underway.

Potato Virus S and Potato Virus X

PVS and PVX are 'contact spread 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 from symptoms is very difficult, particularly in summer crops. The virus can spread quickly from an infected seed lot or crop when hygiene is inadequate.

Testing at seed growers sites detected only nine plants infected with PVS or PVX. The certified seed scheme rules and growers practices appear to be maintaining low levels of PVS and PVX.

Last year 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 0.05% and for PVX it has declined to 0.04%. Only two registered and one certified seed growers crops were found to be infected with PVS and PVX and that at a very low level. The substantial reduction in infection is thought 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 their plants and ensure remedial action is put in place. Remedial action effected as a result of this testing included:

- Disposal of the crop from the seed growers program as either wares, processing or seed depending on the severity of the infection level;

For PLRV and TSWV:

- Retaining plots and applying extra attention to roguing the following crop;
- Retaining plots and applying additional insecticide applications for the remainder of the crop's life and earlier in the life of the following crop;

For PVX and PVS:

- Retaining crops and applying extra attention to hygiene and isolation of the following crop;
- Retaining plots and applying 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 seed tubers.

The Western Australian Seed Advisory Committee has recommended continuation of the program in 2003/2004.

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 agreed by growers or the Seed Advisory Committee. There was an unsuccessful suggestion to move the testing to G3 sown crops, the advantages of this are that the tests would be conducted on seed that would be more likely traded. The acceptance of the leaf test (as opposed to tubers being tested) by Sri Lankan quarantine authorities meant the need for tests on tubers for each seed lot would be reduced.

The results of the PVS and PVX testing will be used to propose the introduction of standards to the Registered Seed Scheme. This will enable rejection of crops identified with excessive levels of plants infected with PVS or PVX for the first time. Continued testing to identify disease outbreaks could see these viruses eliminated from the Registered seed scheme in the near future. The methods used so effectively in Western Australia are being studied by seed schemes in all states through the operations of the Seed Potatoes Australia Group (SPAG) and in particular in Tasmania where a survey has shown seed to be seriously infected.

The results of the PVY testing program are available (along with the results of other tests conducted for the purpose) to the WA quarantine service to monitor the success of the PVY virus eradication program.

Recommendations

1. It is recommended funding for virus-testing of generation two sown crops be continued.
2. The current seed schemes have significantly reduced the level of PVX and PVS present. 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 Registered Seed Scheme crops showing high levels of PVS and PVX.
 - Growers only import seed lots to their properties that are tested clear of these viruses.
3. PVY and PVY^{NTN} testing continue and contribute to knowledge about the success of the current eradication program or conversely the invasion of the seed schemes by this virus.
4. It is recommended that the Seed Potatoes Australia Group consider implementing virus indexing to the National Standard for the Certification of Seed Potatoes to improve the production of low level virus infected seed.

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Appendix

Grower	Variety	No 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	Number of samples infected with PVY
Grower 1	Atlantic	50	0	0	0	0	
Grower 1	Delaware	50	0	0	0	0	0
Grower 1	Eureka	50	0	0	0	0	0
Grower 1	Kennebec	50	0	0	0	0	0
Grower 1	Russet Burbank	80	2.5%	0	0	0	0
Grower 1	Nooksack	50	0	0	0	0	0
Grower 1 Total		280					
Grower 2	Nadine	50	0	0	0	0	
Grower 2	Ruby Lou	50	0	0	0	0	
Grower 2	Delaware	50	0	0	0	0	
Grower 2	Royal Blue	130	0	0	0	0	0
Grower 2	Atlantic	130	0	0	0	0	0
Grower 2	Ruby Lou	130	0	0	0	0	0
Grower 2 Total		540					
Grower 3	Carlingford	50	0	0	0	0	0
Grower 3	Desiree	50	0	0	0	0	0
Grower 3	Nooksack	50	0	0	0	0	0
Grower 3	Atlantic	50	0	0	0	0	0
Grower 3	Mondial	50	0	0	0	0	0
Grower 3	Delaware	50	0	0	0	0	0
Grower 3	Saxon	50	0	0	0	0	0
Grower 3	Carlingford	50	0	0	0	0	0

Grower 3 Total		400					
Grower 4	FL 1867	50	0	0	0	0	0
Grower 4	Delaware	50	0	0	0	0	0
Grower 4	Eureka	50	0	0	0	0	0
Grower 4	Atlantic	45	0	0	1/5 groups*	0	0
Grower 4	Ruby Lou	50	0	0	0	0	0
Grower 4	Royal Blue	50	0	0	0	0	0
Grower 4	Bremer	50	0	0	0	0	0
Grower 4	Spunta	50	0	0	0	0	0
Grower 4	Nooksack	50	0	0	0	0	0
Grower 4	Mondial	50	0	0	0	0	0
Grower 4	Spunta	50	0	0	1/5 groups*	0	0
Grower 4	Bremer	50	0	0	0	0	0
Grower 4	Atlantic	50	0	0	0	0	0
Grower 4 Total		645					
Grower 5	Nooksack	260	0.4%	0	0	0	0
Grower 5	Nadine	250	0	0	0	0	0
Grower 5 Total		510					
Grower 6	Aurora	50	0	0	0	0	
Grower 6	Orion	50	0	0	0	0	
Grower 6	Desiree	75	0	0	0	0	
Grower 6	Sebago	75	0	0	0	0	
Grower 6	Atlantic	75	0	0	0	0	
Grower 6	Nadine	75	0	0	0	0	
Grower 6	Granola	75	0	0	0	0	
Grower 6	Nicola	75	0	0	0	0	

Grower 6	Ruby Lou	75	0	0	0	0	
Grower 6 Total		625					
Grower 7	Shine	50	0	4%	0	0	0
Grower 7	Desiree	50	0	0	0	0	0
Grower 7	Ruby Lou	50	0	0	0	0	0
Grower 7	Desiree	50	0	0	0	0	0
Grower 7	Ruby Lou	100	0	0	0	0	
Grower 7	Atlantic	100	0	5/10 groups*	0	0	0
Grower 7	Nadine	100	0	0	0	0	0
Grower 7	Orion	100	0	9/10 groups*	0	0	0
Grower 7	Orion	100	0	2%	0	0	0
Grower 7	Aurora	100	0	20%	0	0	0
Grower 7 Total		800					
Grower 8	Royal Blue	140	0	0	0	0	0
Grower 8	Nadine	125	0	0	0	0	0
Grower 8	Ruby Lou	120	6%	0	0	0	0
Grower 8	Mondial	125	0.8%	0	0	0	0
Grower 8 Total		510					
Grower 9	Kestrel	50	0	0	0	0	0
Grower 9	Valour	50	0	2/5 groups*	0	0	0
Grower 9	Redgem	50	0	0	0	0	0
Grower 9	Argos	50	0	0	0	0	0
Grower 9	Nadine	50	0	0	0	0	0
Grower 9	Harmony	50	0	0	0	0	0
Grower 9 Total		300					

Grower 10	FL 1867	130	0	0	0	0	0
Grower 10	FL 1867	50	0	0	0	0	0
Grower 10	Atlantic	50	0	0	0	0	0
Grower 10	Atlantic	100	0	0	0	0	0
Grower 10	Atlantic	170	0	0	0	0	0
Grower 10 Total		500					
Grower 11	FL 1867	50	0	0	0	0	0
Grower 11	Ruby Lou	50	0	0	0	0	0
Grower 11	Granola	50	0	0	0	0	0
Grower 11	Delaware	50	0	0	0	3/5 groups*	0
Grower 11	Desiree	50	0	0	0	0	0
Grower 11	Granola	50	0	0	0	0	0
Grower 11	Ruby Lou	50	6%	0	0	0	0
Grower 11	Granola	50	0	0	0	0	0
Grower 11	Ruby Lou	40	12.5%	0	0	0	0
Grower 11	Nadine	40	0	0	0	0	0
Grower 11	Harmony	50	0	0	0	0	0
Grower 11	Ruby Lou	50	8%	0	0	0	0
Grower 11	Granola	50	0	0	0	0	0
Grower 11	Purple Congo	50	16%	0	0	0	0
Grower 11	Mondial	50	0	0	0	0	0
Grower 11	Atlantic	50	0	0	0	0	0
Grower 11	Granola	50	0	0	0	0	0
Grower 11	Russet Burbank	50	8%	0	0	0	0
Grower 11 Total		880					
Grower 12	Atlantic	170	0	0	0	0	0

Grower 12	Atlantic	160	0	0	0	0	0
Grower 12	Atlantic	170	0	0	0	0	0
Grower 12 Total		500					
Grower 13	Eureka (Potato)	250	10%	0	0	0	0
Grower 13	Ruby Lou	250	0	0	0	0	0
Grower 13 Total		500					
Grower 14	Granola	250	0	0	0	0	0
Grower 14	Atlantic	500	0.2%	0	0	0	0
Grower 14 Total		750					
Grower 15	Nadine	170	0	0	0	0	0
Grower 15	Valour	170	0	0	0	0	0
Grower 15	Kestrel	170	0	0	0	0	0
Grower 15 Total		510					
Grower 16	Atlantic	500		0	0	0	
Grower 16 Total		500					
Grower 17	Atlantic	125	0	0	0	0	0
Grower 17	Atlantic	125	0	0	0	0	0
Grower 17	Atlantic	80	0	0	0	0	0
Grower 17	Atlantic	50	0	0	0	0	0
Grower 17	Atlantic	50	0	0	0	0	0
Grower 17 Total		430					
Grower 18	Delaware	250	0	0	2/25 groups*	0	0
Grower 18	Carlingford	250	1.2%	0	0	0	0
Grower 18 Total		500					
Grower 19	FL 1867	50	0	0	0	0	0

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Grower 19	Delaware	50	0	0	0	0	0
Grower 19	Atlantic	50	0	0	0	0	0
Grower 19	Dawmor	50	0	0	0	0	0
Grower 19 Total		200					
Grower 20	Dawmor	50	0	0	0	0	0
Grower 20	FL 1867	70	0	0	0	0	0
Grower 20	Nadine	50	0	0	0	0	0
Grower 20	Eureka	50	0	0	0	0	0
Grower 20 Total		220					
Grower 21	Atlantic	70	1.7%	0	0	0	0
Grower 21	Eureka	70	0	0	0	0	0
Grower 21	Ruby Lou	70	1.7%	0	0	0	0
Grower 21	Carlingford	70	0	0	0	0	0
Grower 21	Nooksack	70	0	0	0	0	0
Grower 21 Total		350					
Grand Total		10450					

* Number of positive plants
per group. 10 plants per
group