Ministry for Primary Industries
Manatū Ahu Matua

Import Risk Analysis: Viruses, Viroids, Phytoplasma, Bacteria and Diseases of Unknown Aetiology on *Malus* Nursery Stock from all Countries

July 2012

New Zealand Government

Growing and Protecting New Zealand

New Zealand Ministry for Primary Industries
Pastoral House
25 The Terrace
PO Box 2526
Wellington 6140
New Zealand

Tel: 64 4 894 0100
Fax: 64 4 894 0222

Draft Import Risk Analysis: Viruses, Viroids, Phytoplasma, Bacteria and Diseases of Unknown Aetiology on *Malus* Nursery Stock

July 2012

Approved for Distribution

Christine Reed
Manager, Biosecurity Science and Risk Assessment
Ministry for Primary Industries

Contributors to this risk analysis

The following people provided significant input into the development of this risk analysis:

Primary Authors

Dr Mike Ormsby	Senior Adviser, Plants Risk Analysis	MAF Biosecurity New Zealand, Wellington
Lihong Zhu	Senior Adviser, Plants Risk Analysis	MAF Biosecurity New Zealand, Wellington

Secondary Contributors

Ali Loughnan	Adviser Marine Response	MAF Biosecurity New Zealand, Wellington
Daniel Jones	Senior Adviser, Plants Risk Analysis	MAF Biosecurity New Zealand, Wellington
Dr José Derraik	Senior Adviser, Plants Risk Analysis	MAF Biosecurity New Zealand, Wellington

Scientific Review

Michael Pearson	Associate Professor	Faculty of Science, The University of Auckland, Auckland, New Zealand
Joseph Postman	Plant Pathologist	USDA Agricultural Research Service, National Clonal Germplasm Repository, Corvallis, Oregon USA
Delano James	Research Scientist Head, Research Section	Centre for Plant Health Canadian Food Inspection Agency, British Colombia, Canada

Many others for MAF and other agencies assisted in advice and support and their contributions are gratefully appreciated.

NOTE: Drafting of this risk analysis was completed in mid 2009 and this text has not been significantly updated since.

Contents

Page

Executive summary ... 1
1.Project background and process ... 4
1.1. Risk analysis background ... 4
1.2. Risk analysis process and methodology ... 5
1.3. References for chapter 1 ... 7
2.Commodity and pathway descriptions ... 8
2.1. Commodity description ... 8
2.2. Introduction to the genus *Malus* ... 8
2.3. Biology and ecology of *Malus domestica* ... 9
2.4. The apple industry in New Zealand ... 10
2.5. Description of the existing import pathway ... 11
2.6. References for chapter 2 ... 11
3.Hazard identification ... 13
3.1. Potential hazard organisms ... 13
3.2. Organisms and diseases recorded on *Malus* ... 15
3.3. References for chapter 3 ... 17
4.General phytosanitary measures for nursery stock ... 18
4.1. Important generic risk factors ... 18
4.2. Collection, handling and storage of budwood ... 18
4.3. Disease symptom expression and testing ... 19
4.4. References for chapter 4 ... 23
5.Risk analyses – Viruses ... 25
5.1. Apple latent spherical virus (ALSV) ... 25
5.2. Carnation ringspot virus (CRSV) ... 29
5.3. Cherry rasp leaf virus (CRLV) ... 35
5.4. Clover yellow mosaic virus (ClYMV) ... 44
5.5. Horseradish latent virus (HRLV) ... 49
5.6. Sowbane mosaic virus (SoMV) ... 51
5.7. Tomato bushy stunt virus (TBSV) ... 53
5.8. Tomato ringspot virus (ToRSV) ... 58
5.9. Tulare apple mosaic virus (TAMV) ... 66
6.Risk analyses – Viroids ... 70
6.1. Apple dimple fruit viroid (ADFVd) ... 70
6.2. Apple fruit crinkle viroid (AFCVd) ... 75
6.3. Apple scar skin viroid (ASSVd) ... 79
6.4. Peach latent mosaic viroid (PLMVd) ... 84
7.Risk analyses - Phytoplasma ... 86
7.1. *Candidatus* Phytoplasma *asteris* (ApSL) ... 86
7.2. *Candidatus* Phytoplasma *mali* (AP, AT) ... 90
7.3. *Candidatus* Phytoplasma *pyri* (PD) ... 97
8.Risk analyses - Diseases of unknown aetiology ... 98
8.1. Apple blister bark agent ... 98
8.2. Apple brown ringspot agent ... 103
8.3. Apple bumpy fruit agent ... 107
8.4. Apple bunchy top agent ... 112
8.5. Apple dead spur agent ... 114
8.6. Apple decline agent ... 118
8.7. Apple freckle scurf agent ... 122
8.8. Apple green dimple and ring blotch agent ... 126
8.9. Apple junction necrotic pitting agent ... 130

8.10. Apple McIntosh depression agent 134
8.11. Apple narrow leaf agent 138
8.12. Apple necrosis agent 142
8.13. Apple necrotic spot & mottle agent 143
8.14. Apple Newton wrinkle agent 144
8.15. Apple painted face agent 148
8.16. Apple pustule canker agent 150
8.17. Apple red ring agent 155
8.18. Apple rosette agent 159
8.19. Apple rough skin agent 163
8.20. Apple russet wart agent 167
8.21. Apple star crack agent 171
8.22. Apple transmissible internal bark necrosis agent 176
8.23. Quince yellow mosaic agent 181
9. Risk analyses - Bacteria 182
9.1. *Pseudomonas syringae* pv. *papulans* 182
Glossary of Terms 190
References for glossary of terms 193
Appendix 1 Potential hazards – descriptions and references 194
References for Appendix 1 203

Executive summary

The risks of viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology associated with the importation of *Malus* nursery stock from all countries have been examined.

An initial list of 64 viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology recorded on *Malus* nursery stock that are exotic to New Zealand or are the subject of a national eradication campaign in New Zealand, were included in a preliminary potential hazard list. Forty of these were considered potential hazards and were subjected to a risk assessment. A list of the final hazard status of the potential hazards is provided in table 1.1 below, along with a brief description of the phytosanitary measures considered in the analysis as potential options for managing the identified risks. Further details on the phytosanitary measures options are provided in chapter 4 of this risk analysis and in the chapters relating to each of for the hazards or hazard groups as listed. In addition to the options presented, no phytosanitary measures may also be considered.

Of particular note within the table are 12 of the hazards marked with an asterisk (*). While these organisms and diseases are considered hazards, their impacts are largely limited to the production sector. The production sector is the greatest beneficiary of trade in *Malus* nursery stock material and in these cases has the ability to limit any consequences associated with the establishment of these hazards in New Zealand. In consultation with affected domestic sectors the biosecurity risks from these hazards may be managed by industry alone rather than using official quarantine controls.

Table 1.1: Potential hazards – Status determination and identified phytosanitary measures options

Organism (Name and organism type)	Hazard?	Phytosanitary measures that could be considered options for the effective management of the identified hazards, subject to effective implementation.
Viruses (Chapter 5)		
Horseradish latent virus Sowbane mosaic virus	No	Assessed as not being a hazard therefore no phytosanitary measures are required.
Apple latent spherical virus Tulare apple mosaic virus	Yes	a. No phytosanitary measures if risk considered acceptable; b. Virus indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.
Carnation ringspot virus Tomato bushy stunt virus	Yes	a. Virus indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.
Cherry rasp leaf virus Clover yellow mosaic virus Tomato ringspot virus	Yes	a. Pest free area (PFA): *Malus* nursery stock is imported from areas that are free of these viruses; b. Pest free place of production (PFPP): *Malus* nursery stock is imported from places of production that are free of these viruses; c. Virus indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.
Viroids (Chapter 6)		
Peach latent mosaic viroid	No	Assessed as not being a hazard therefore no phytosanitary measures are required.
Apple dimple fruit viroid	Yes*	a. Risks managed by industry without official controls; b. Viroid indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.
Apple fruit crinkle viroid	Yes	a. Viroid indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.

Organism (Name and organism type)	Hazard?	Phytosanitary measures that could be considered options for the effective management of the identified hazards, subject to effective implementation.
Apple scar skin viroid	Yes	a. Pest free area (PFA): *Malus* nursery stock is imported from areas that are free of these viroids; b. Pest free place of production (PFPP): *Malus* nursery stock is imported from places of production that are free of these viroids; c. Viroid indexing: Inoculation (onto a susceptible *Malus* cultivar or other host plant) followed by testing of symptomatic material.
Phytoplasma (Chapter 7)		
Candidatus Phytoplasma *pyri*	No	Assessed as not being a hazard therefore no phytosanitary measures are required.
Candidatus Phytoplasma *asteris* *Candidatus* Phytoplasma *mali*	Yes	a. Pest free area (PFA): *Malus* nursery stock is imported from areas that are free of these phytoplasma; b. Pest free place of production (PFPP): *Malus* nursery stock is imported from places of production that are free of these phytoplasma; c. Phytoplasma indexing using nested-PCR and universal phytoplasma primers.
Diseases of unknown aetiology (Chapter 8)		
Apple bunchy top Apple necrosis Apple necrotic spot & mottle Apple painted face Quince yellow mosaic	No	Assessed as not being a hazard therefore no phytosanitary measures are required.
Apple brown ringspot Apple McIntosh depression	Yes	a. No phytosanitary measures if risk considered acceptable; b. Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 2-year period.
Apple blister bark Apple bumpy fruit Apple Newton wrinkle Apple red ring Apple star crack	Yes*	a. Risks managed by industry without official controls; b. Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 2-year period.
Apple green dimple & ring blotch Apple rosette Apple transmissible internal bark necrosis	Yes*	a. Risks managed by industry without official controls; b. Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 3-year period.
Apple junction necrotic pitting	Yes*	a. Risks managed by industry without official controls; b. Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 2-year period.
Apple narrow leaf	Yes	a. No phytosanitary measures if risk considered acceptable; b. Indexing of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 2-year period.
Apple freckle scurf Apple pustule canker	Yes*	a. Risks managed by industry without official controls; b. Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 4-year period.
Apple dead spur Apple russet wart	Yes	Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 2-year period.
Apple decline	Yes	Inspection of mother plants: Inspection of imported nursery stock over a 2-year period.

Organism (Name and organism type)	Hazard?	Phytosanitary measures that could be considered options for the effective management of the identified hazards, subject to effective implementation.
Apple rough skin	Yes	Indexing/inspection of mother plants: Indexing (onto a susceptible *Malus* cultivar) or inspection of imported nursery stock over a 3-year period.
Bacteria (Chapter 9)		
Pseudomonas syringae pv. *papulans*	Yes	a. Pest free area (PFA): *Malus* nursery stock is imported from areas that are free of this bacterium; b. Pest free place of production (PFPP): *Malus* nursery stock is imported from places of production that are free of this bacterium; c. Indexing (onto a susceptible *Malus* cultivar or other host plant over a 2-year period) or PCR testing of mother plants.

1. Project background and process

1.1. Risk analysis background

This import risk analysis (IRA) aims to identify risk mitigating options for the development of one or more import health standards (IHS) for managing the biosecurity risks from viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology that may be associated with *Malus* nursery stock being imported into New Zealand.

Within the genus *Malus* is the hybrid species *Malus domestica* (considered a hybrid of at least four different wild species including *M. sylvestris*, *M. pumila*, *M. dasyphylla* and *M. sieversii*) which is more commonly known as the commercial apple (Sauer 1993). Apples are an important high value crop for the New Zealand horticultural industry with an annual trade value in 2005 of $NZ 440 million. Apple plants are associated internationally with a number of important plant pests and diseases, many of which can be vectored on other species within the *Malus* genus. Other species of *Malus* are also important to the New Zealand industry as sources of genetic breeding stock in the development of new apple varieties. New genetic breeding stock can be used to:

- obtain the benefits of individual characteristics of specific stocks, such as growth rates and eventual height, resistance to disease and insects, tolerance to different soil types;
- change an existing cultivar on a tree. This is normally used in fruit growing where it may be desirable to replace one cultivar on a mature tree with another;
- produce "novelty trees" or obtain special forms of plants;
- be used in virus indexing in research or diagnostic programmes to detect viruses during the cleaning of virus-infected stock and produce virus-free clones.

A review of an existing IHS for *Malus*, namely the IHS for *Malus domestica* Nursery Stock (budwood/ cuttings) (MAF –RA-PL-20/9, June 1998) identified a number of areas of concern both from a biosecurity perspective and one of trade:

(i) There is no risk analysis document supporting this existing IHS;

(ii) Some exotic organisms known to be associated with *Malus* budwood are not on the list of hazard organisms, and there are organisms that are listed as regulated (hazards) but possibly should not be;

(iii) Some of the taxonomy of the organisms may need to be reviewed;

(iv) The testing and treatment requirements need to be updated with more recent developments in this area;

(v) Operational requirements as they are currently stated, such as Level 3 post-entry quarantine, can not easily be met;

(vi) A number of the measures (phytosanitary requirements) need to be revised in line with current practices.

While the current IHS allows *Malus* nursery stock (budwood, cuttings and plants *in vitro*) to be imported directly into New Zealand level 3 post-entry quarantine facilities, this has rarely been able to occur. Problems with the current standard have meant that such material has only been able to come in from overseas-accredited quarantine facilities and then spend more than six months in Level 2 Post Entry Quarantine in New Zealand. These issues principally relate to the detection and management of viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology that may be associated with the imported nursery stock material. The New Zealand apple industry considers this is an important restriction on trade and has requested that a new standard be developed to allow imports while providing an appropriate level of biosecurity for New Zealand.

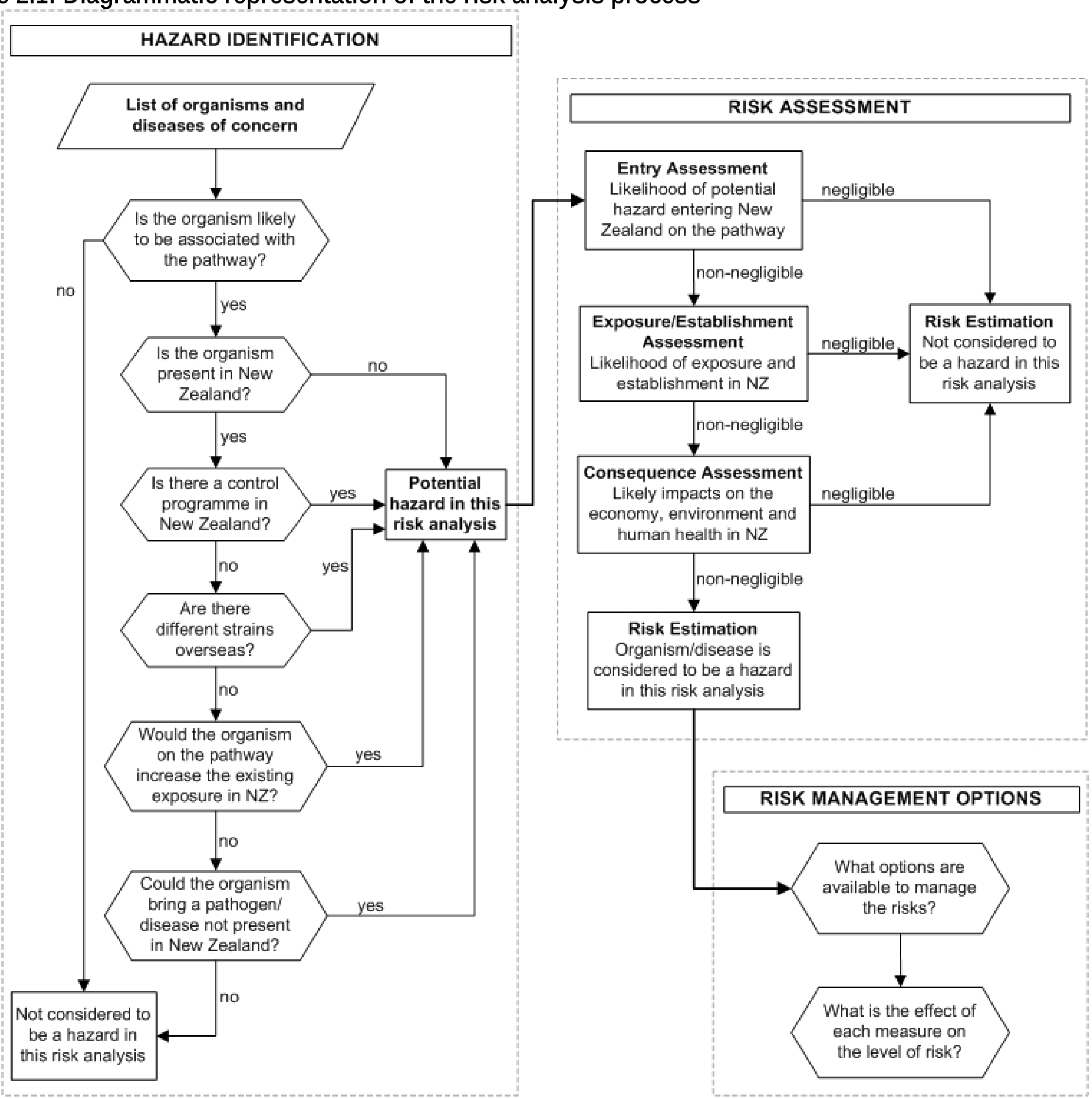
The purpose of this risk analysis is therefore to identify the biosecurity risks of any viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology potentially associated with the importation of *Malus* nursery stock into New Zealand, and identify appropriate management measures in accordance with current MAF policies. The completed risk analysis will then form the basis of the review of any existing import health standards for *Malus* nursery stock.

1.2. Risk analysis process and methodology

The following briefly describes the MAF Biosecurity New Zealand process and methodology for undertaking import risk analyses. For a more detailed description of the process and methodology please refer to the Biosecurity New Zealand Risk Analysis Procedures (Version 1 12 April 2006) which is available on the Ministry of Agriculture and Forestry web site[1].

The risk analysis process leading to the final risk analysis document is summarised in Figure 2.1.

Figure 2.1: Diagrammatic representation of the risk analysis process



1 http://www.biosecurity.govt.nz/files/pests/surv-mgmt/surv/review/risk-analysis-procedures.pdf

The process outlined in figure 2.1 is further supported by the following:

1.2.1. Assessment of uncertainties

In this aspect of the risk analysis process the uncertainties and assumptions identified during the preceding hazard identification and risk assessment stages are summarised. An analysis of these uncertainties and assumptions can then be completed to identify which are critical to the outcomes of the risk analysis. Critical uncertainties or assumptions can then be considered for further research with the aim of reducing the uncertainty or removing the assumption.

Where there is significant uncertainty in the estimated risk, a precautionary approach to managing risk may be adopted. In these circumstances the measures should be reviewed as soon as additional information becomes available[2] and be consistent with other measures where equivalent uncertainties exist.

1.2.2. Risk management

For each organism classified as a hazard, a risk management step is carried out, which identifies the options available for managing the risk. In addition to the options presented, no phytosanitary measures may also be considered for each hazard. Feedback is sought from stakeholders on these options through consultation. Risk analyses are then be finalised following this consultation and will present options – refined if appropriate –for the Import health standard process to consider. Measures will only be recommended to the Chief Technical Officer for decision once the import health standard process is complete.

As obliged under Article 3.1 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement 1995), the measures adopted in IHSs will be based on international standards, guidelines and recommendations where they exist, except as otherwise provided for under Article 3.3 (where measures providing a higher level of protection than international standards can be applied if there is scientific justification, or if there is a level of protection that the member country considers is more appropriate following a risk assessment).

1.2.3. Review and consultation

Peer review is a fundamental component of a risk analysis to ensure the analysis is based on the most up to date and credible information available. Each analysis must be submitted to a peer review process involving appropriate staff within those government departments with applicable biosecurity responsibilities, and recognised and relevant experts from New Zealand or overseas. The critique provided by the reviewers is reviewed and where appropriate, incorporated into the analysis. If suggestions arising from the critique are not adopted the rationale must be fully explained and documented.

Once a risk analysis has been peer reviewed and the critiques addressed it is then published and released for public consultation. The period for public consultation is usually 6 weeks from the date of publication of the risk analysis.

All submissions received from stakeholders will be analysed and compiled into a review of submissions. Either a document will be developed containing the results of the review or

2 Article 5.7 of the SPS Agreement states that "a Member may provisionally adopt sanitary …. measures" and that "Members shall seek to obtain additional information …. within a reasonable period of time." Since the plural noun "Members" is used in reference to seeking additional information a co-operative arrangement is implied between the importing and exporting country. That is the onus is not just on the importing country to seek additional information.

proposed modifications to the risk analysis or the risk analysis itself will be edited to comply with the proposed modifications.

1.3. References for chapter 1

MAF (2006) Biosecurity New Zealand risk analysis procedures. Ministry of Agriculture and Forestry, New Zealand, 201 pp. Available online at http://www.biosecurity.govt.nz/files/pests-diseases/surveillance-review/risk-analysis-procedures.pdf

Sauer J D (1993) Historical geography of crop plants - a select roster. *CRC Press*, Boca Raton, Florida

SPS Agreement (1995) World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures. World Trade Organization, Geneva

2. Commodity and pathway descriptions

2.1. Commodity description

The scope of this risk analysis is the analysis of the risks of any viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology potentially associated with *Malus* nursery stock imported into New Zealand. For the purposes of this analysis "nursery stock" is defined as:

> "*Whole plants or parts of plants imported for growing purposes, e.g. cuttings, scions, budwood, marcots, off-shoots, root divisions, bulbs, corms, tubers and rhizomes*"

For the purposes of this analysis "budwood", a type of nursery stock is defined as:

> "*The mature or semi-mature stems harvested as a source of bud eyes for new propagation*"

Plants *in-vitro*, another type of nursery stock, is defined under the IPPC (FAO 2007) as:

> "*A commodity class for plants growing in an aseptic medium in a closed container*"

Only *Malus* budwood and plants *in vitro* are considered in this risk analysis.

The *Malus* species under consideration includes all of the species currently approved for import into New Zealand. Plant species approved for import into New Zealand are listed on MAF's Plant Biosecurity Index which is currently available on MAF Biosecurity New Zealand's web site[3].

2.2. Introduction to the genus *Malus*

Malus, the apples, is a genus of about 42 known species of small deciduous trees or shrubs in the family Rosaceae, order Rosales, including most importantly the domesticated "orchard apple" or "table apple" (*M. domestica*, considered a hybrid of at least four different wild species including *M. sylvestris*, *M. pumila*, *M. dasyphylla* and *M. sieversii*) (Table 3.1) (Sauer 1993, Luby 2003, USDA ARS 2008). The other species are generally known as "wild apples", "crab apples" or "crabs", this name being derived from their small and sour, unpalatable fruit. The genus is native to the temperate zone of the Northern Hemisphere, in Europe, Asia and North America (Luby 2003).

Table 3.1: Recorded species in the *Malus* genus

Malus angustifolia (Aiton) Michx.	*Malus melliana* (Hand.-Mazz.) Rehder
Malus baccata (L.) Borkh.	*Malus muliensis* T. C. Ku
Malus baoshanensis G. T. Deng	*Malus ombrophila* Hand.-Mazz.
Malus bhutanica (W. W. Sm.) J. B. Phipps	*Malus orientalis* Uglitzk.
Malus brevipes (Rehder) Rehder	*Malus orthocarpa* Lavallee ex anon.
Malus chitralensis Vassilcz.	*Malus prattii* (Hemsl.) C. K. Schneid.
Malus coronaria (L.) Mill.	*Malus prunifolia* (Willd.) Borkh.
Malus domestica Borkh.	*Malus pumila* Mill.
Malus doumeri (Bois) A. Chev.	*Malus sargentii* Rehder

3 http://www1.maf.govt.nz/cgi-bin/bioindex/bioindex.pl

Malus florentina (Zuccagni) C. K. Schneid.	*Malus sieversii* (Ledeb.) M. Roem.
Malus floribunda Siebold ex Van Houtte	*Malus sikkimensis* (Wenz.) Koehne ex C. K. Schneid.
Malus fusca (Raf.) C. K. Schneid.	*Malus spectabilis* (Aiton) Borkh.
Malus halliana Koehne	*Malus spontanea* (Makino) Makino
Malus honanensis Rehder	*Malus sylvestris* (L.) Mill.
Malus hupehensis (Pamp.) Rehder	*Malus toringo* (Siebold) Siebold ex de Vriese
Malus ioensis (Alph. Wood) Britton	*Malus transitoria* (Batalin) C. K. Schneid.
Malus kansuensis (Batalin) C. K. Schneid.	*Malus trilobata* (Poir.) C. K. Schneid.
Malus komarovii (Sarg.) Rehder	*Malus tschonoskii* (Maxim.) C. K. Schneid.
Malus leiocalyca S. Z. Huang	*Malus yunnanensis* (Franch.) C. K. Schneid.
Malus maerkangensis M. H. Cheng et al.	*Malus zhaojiaoensis* N. G. Jiang
Malus mandshurica (Maxim.) Kom. ex Skvortsov	*Malus zumi* (Matsum.) Rehder

2.3. Biology and ecology of *Malus domestica*

Malus domestica is a small to medium-sized tree, 5-10 m tall, freely branching with long shoots and various types of short shoots (spurs) with a single trunk. When growing unattended in the tropics the plants revert to a stiff upright bush, 2-4 m tall, through reiteration of axes near the ground. Young stems and twigs are tomentose with the leaves being elliptic-ovate, 4-13 cm by 3-7 cm in size, rounded at the base, the margins irregularly saw-toothed, and usually densely tomentose beneath (CPC 2007).

At high latitudes *Malus domestica* requires a mild growing season (no extremes of sunshine, temperature or humidity), a sufficiently cold winter to break dormancy and excellent soil conditions to limit stress, as this affects fruit quality and, if more severe, fruit size and floral development for the next crop. Windbreaks are needed for exposed sites. In the tropics a short growth cycle requires favourable (mild) growing conditions throughout the year, as may be found close to the equator: altitude 800-1200 m (temperature 16-27°C), sunshine more than 50% of potential sunshine duration, rainfall 1600-3200 mm, relative humidity 75-85%, good soils with irrigation facilities. For an annual growth cycle in the tropics there should be a prominent change of seasons, the growing season meeting the above requirements, whereas the off-season should preferably be overcast as well as cool, since low light levels as well as low temperature appear to have a dormancy-breaking effect. Such conditions are usually found further from the equator at elevations of 1200-1800 metres (CPC 2007).

Growth flushes are terminated by the formation of inflorescences (consisting of 2-5 flowers with a terminal “king” flower), or vegetative spurs. Flowers are insect-pollinated, and the fruit ripens 3.5-5 months after flowering, depending on the cultivar. During fruit development, some lateral, undeveloped buds develop floral structures within the protective budscales. After a period of dormancy, these buds will grow out to form the next season’s inflorescences. Buds that did not develop floral structures will grow as a vegetative spur, or will not grow at all.

In temperate climates such as New Zealand, there is usually a single major flush in spring. Fruit ripens in the autumn after which the leaves are shed. Low winter temperatures are instrumental in breaking bud dormancy in time for the spring flush.

In the tropics growth is very different: shoots all grow more or less vertically, leaves are retained much longer so that the plant becomes evergreen, there is little shoot growth, scattered over the entire year and largely limited to shoot extension, few laterals being formed (CABI, 2006).

Flowering and fruiting are sporadic throughout the year. In cultivation this undesirable trait is suppressed by bending shoots horizontal to build a wide tree frame and by enforcing a synchronous growth cycle, either an annual cycle, through appropriate dormancy-breaking treatments, or a much shorter cycle based on triggering a flush with bloom before bud dormancy has become too deep to be broken by defoliation. In the latter system trees may produce two crops per year as in East Java. At high latitudes much attention has to be paid to cross-pollination by compatible cultivars. Under the favourable conditions for flowering in the tropics, however, the importance of self- and cross-incompatibility is much reduced; even parthenocarpic fruit set is fairly common (CPC 2007).

2.3.1. Propagation and planting of *Malus domestica*

Apples are always cloned and as most cultivars can hardly be propagated on their own roots, budding, generally T-budding, is the standard propagation method. In the tropics seedling rootstocks are often imported; in several countries clonal rootstocks of the MM-series (Malling-Merton hybrids, originally bred in England to impart resistance against over wintering woolly aphids) are used with limited success. In Indonesia a rootstock, named 'wild apple' or sometimes 'Chinese crab apple', is used exclusively; it is multiplied either by collecting root suckers in the orchards or by air layering (CPC 2007).

In the nursery as well as in the orchard it is vitally important to work with young shoots, to avoid the problems of deepening dormancy of the buds. Thus rootstocks are budded young with young budwood and the trees are sold with young scion wood, the more so since transplanting sets back tree vigour. Budded trees are defoliated and pruned as soon as extension growth stops, in order to shape the tree frame but also to induce another flush of young shoots. The emphasis on young material implies that everything should be done to maintain high growth rates, so that this young material is sufficiently sturdy to work with. Potted trees can be sold in leaf, but bare-rooted trees should be defoliated. The trees are planted at 3 x 2.5 m or in double rows, spacing (3.5 + 1.5) x 2 m, giving densities of 1333 to 2000 trees per hectare (CPC 2007).

2.3.2. Distribution and production of *Malus domestica*

The cultivated apple of today is believed to have been derived from south-west Asia. At present apples are cultivated all over the world. Main areas of cultivation are Western Europe, the former Soviet Union, China, the USA, Turkey, Iran, Japan and Argentina (CPC 2007).

World production of apples, which increased by almost 4% per annum during the 1990s, has slowed and the rate of increase has dropped below 1% per year. In 2004 China produced about 21 million tonnes each year, which was 36% of world production. New Zealand was ranked second behind Chile among 28 apple-producing countries in 2003, judged on 22 criteria: viz. production efficiency, industry infrastructure and inputs, and financial and market factors. France, Netherlands, Austria, and Belgium were next in line (Anonymous 2004).

2.4. The apple industry in New Zealand

Apples were New Zealand's second largest horticultural export product for the year ended March 2005, valued at $NZ 485 million. The main varieties of apple currently grown in New Zealand are Braeburn and Royal Gala, with production of Pacific Rose increasing. The major markets for New Zealand apples are the European Union, especially the United Kingdom, and the United States (MAF 2008, Growingfutures 2004).

Apples represent around 25 percent of New Zealand's horticultural export earnings, reaching $NZ 488 million (FOB) in 1999. Apple production in 1999 was about 612 000 tonnes, equivalent to about 34 million 18 kg cartons. Of these, 17.7 million cartons or just over 50%

were exported. The world apple industry is very competitive and New Zealand produces less than one percent of world apple production. Only 6 percent of the total world production is exported (excluding trade within the EU), and New Zealand accounts for between 5 to 14% of this. The world's biggest apple producing countries are South Africa, Chile, Argentina, the US and the European Union (MAF 2008, Growingfutures 2004).

The apple industry is a major employer in New Zealand, with an estimated 8,500 people employed directly and 11,600 in total. The main apple producing areas in New Zealand are Hawke's Bay in the North Island and Nelson (Tasman) in the South Island (Statistics NZ 2008).

2.5. Description of the existing import pathway

MAF, operating under the powers of the Biosecurity Act 1993, has in place an import health standard and clearance procedures that provides two main forms of general risk mitigation measures for *Malus* nursery stock:

1. Basic conditions to be met by all imported nursery stock (MAF 2005); and
2. A period in post-entry quarantine (MAF 1999, MAF 2003).

Currently *Malus* nursery stock may be imported into New Zealand via two main pathways. Either:

a. from an offshore accredited plant quarantine facility into a New Zealand Level 2 or Level 3 post-entry quarantine facility; or

b. from elsewhere in the world into a New Zealand Level 3 post-entry quarantine facility.

Offshore plant quarantine facilities can only be used if the facility and operator first receive accreditation from MAF in accordance with the MAF standards (MAF 2001), and have agreed to undertake the phytosanitary measures that are necessary to meet New Zealand's import requirements. The official agreement between accredited offshore plant quarantine facilities and MAF specifies which tests are to be conducted at offshore facility and which tests are to be completed in New Zealand to ensure that all of the import requirements are met according to the MAF.

2.6. References for chapter 2

Anonymous (2004) World Apple Review. Belrose Inc.

CPC (2007) Crop Protection Compendium on Internet. CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

FAO (2007) ISPM No 5 Glossary of phytosanitary terms. Available at: https://www.ippc.int/IPP/En/default.jsp

Growingfutures (2004) New Zealand horticulture facts and figures 2004. Fruits, flowers and vegetables. http://www.hortresearch.co.nz/files/aboutus/factsandfigs/ff2004.pdf

Luby J J (2003) Taxonomic classification and brief history. In Ferree D C and Warrington I J (eds); Apples: Botany, Production and Uses. *CAB International*.

MAF (1999) PBC-NZ-TRA-PQCON: Specification for the Registration of a Plant Quarantine or Containment Facility, and Operator (November 1999). Available at: http://www.biosecurity.govt.nz/border/transitional-facilities/plants/pbc-nz-tra-pqcon.htm

MAF (2001) PIT.OS.TRA.ACPQF: Accreditation of Offshore Plant Quarantine Facilities and Operator (October 2001): Available at: http://www.biosecurity.govt.nz/border/transitional-facilities/plants/pit-os-tra-acpqf.htm

MAF (2003) PP42: Inspection and Clearance of Plant Products held in Post-Entry Quarantine (June 2003). This document is not available for general release.

MAF (2005) 155.02.06: Importation of Nursery Stock (200). Available at:

MAF (2008) Horticulture. *MAF Information Services*. Available at http://www.maf.govt.nz/mafnet/rural-nz/agriculture-forestry-horticulture-in-brief/2005/index.htm; Accessed December 2008.

Sauer J D (1993) Historical geography of crop plants - a select roster. *CRC Press*, Boca Raton, Florida

Statistics NZ (2008) Agricultural Production Statistics (Final): June 2007. Available online at http://www.stats.govt.nz

USDA ARS (2008), National Genetic Resources Program. *Germplasm Resources Information Network - (GRIN)* [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/cgi-bin/npgs/html/genform.pl (21 October 2008)

3. Hazard identification

Species of *Malus* are grown in most countries of the world with *Malus domestica* having by far the largest global distribution of all the species. These species have therefore been exposed to organisms and diseases that are not found in the natural range of this genus. Where *Malus domestica* is grown commercially in significant quantities and is supported by a relatively well-developed plant protection industry, an accurate and relatively complete record of the associated organisms or diseases should be available. For many other countries, however, *Malus* species may be widespread but as domestic amenity plants only, having little commercial value and no or little supporting plant protection industry. Records of associated organisms or diseases in these countries would be expected to be unreliable and incomplete. Therefore while the scope of this risk analysis includes *Malus* nursery stock imported from any country in the world, the information supporting the development of the hazard organism lists in reality originates from a relatively small number of commercially significant apple producing countries.

It is the recommendation of this risk analysis that the considerable uncertainty associated with these secondary countries be considered either in the measures applied in the associated import health standard or through the countries allowed to export *Malus* material to New Zealand.

3.1. Potential hazard organisms

Within this risk analysis the only potential hazard organisms under consideration are the viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology.

3.1.1. Viruses

The Oxford English Dictionary defines a "*virus*" as:

> *"An infectious organism that is usually sub microscopic, can multiply only inside certain living host cells (in many cases causing disease) and is now understood to be a non-cellular structure lacking any intrinsic metabolism and usually comprising a DNA or RNA core inside a protein coat"*

This includes umbraviruses that have no virion protein genes of their own, and use the virion proteins of their symbiotic helper viruses instead (Brunt *et al*. 1996).

A virus is an elementary bio-system that possesses some of the properties of living systems such as having a genome and being able to adapt to changing environments. However, viruses cannot capture and store free energy and they are not functionally active outside their host cells (Fauquet *et al.* 2005). Virus particles (virions) consist of nucleic acid surrounded by proteins, the protein coat or capsid. The shape and dimensions of virus particles are characteristic of each virus. The virus genome consists of either ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) in either single- or double-stranded form, though most contain single stranded RNA (Bokx & van der Want 1987). There are no recorded instances of plant viruses causing diseases in humans.

3.1.2. Viroids

The Oxford English Dictionary defines a "*viroid*" as:

> *"An infectious entity similar to a virus but smaller and consisting of a strand of nucleic acid only, without the protein coat characteristic of a virus"*

Viroids are pathogens that are present in all parts of the plant, both vegetative (roots, shoots, leaves, tubers) and reproductive (flowers, seed). Viroids exist in plants as a protein-free unencapsulated circular RNA molecule. Viroids consist of a covalently closed circular RNA that shows a high degree of base pairing, which results in a thermodynamically stable structure consisting of loops and helices. Viroid RNA does not code for any proteins and depends on the host plant for replication and circularization. Viroids are considered parasites of the transcription machinery of the cell, while viruses are parasites of the translation process (Constable *et al.* 2006).

Viroids can be classified into two families, the *Avsunviroidae* and the *Pospiviroidae,* according to their structure. There are a total of five genera in the former and two in the latter family. When sequence similarity between closely related viroid strains is greater than 90%, they are called variants of the one-viroid species. If there is less than 90% similarity, the viroid strain is considered a new and a distinct species (Constable *et al.* 2006).

3.1.3. Bacteria

The Oxford English Dictionary defines a "*bacterium*" as:

> *"Any of several types of microscopic or ultramicroscopic single-celled organisms very widely distributed in nature, not only in soil, water, and air, but also on or in many parts of the tissues of plants and animals, and forming one of the main biologically interdependent groups of organisms in virtue of the chemical changes which many of them bring about, e.g. all forms of decay and the building up of nitrogen compounds in the soil"*

Bacteria are prokaryotes and are generally single-celled micro-organisms that have a cell membrane, a rigid cell wall, and often one or more flagella. The cytoplasm contains small (70S) ribosomes and DNA that are not bound within organelles. Bacteria form into a number of shapes and some can transform themselves into or produce spores. Almost all plant-pathogenic bacteria are rod-shaped and range from 0.6 to 3.5 µm in length (Agrios 2005).

3.1.4. Phytoplasma

According to the USDA Phytoplasma Resource Centre[4], "*phytoplasma*" are:

> *"Very small bacteria that are enveloped only by a single membrane and do not possess a cell wall like typical bacteria"*

Phytoplasma are also prokaryotes and are single-celled micro-organisms that have a cell membrane but lack a rigid cell wall. From a taxonomic and structural perspective phytoplasma are otherwise as bacteria although without a rigid cell wall they cannot form pre-determined shapes.

3.1.5. Diseases of unknown aetiology

"*Diseases of unknown aetiology*" are diseases or disorders of plants, in this case *Malus* species, for which science has yet to find a causative organism or group of organisms. It is therefore possible that a disease of unknown aetiology may not in fact be a disease but rather a physiological condition, or may be caused by a known organism attributed to a separate condition.

4 http://www.ba.ars.usda.gov/data/mppl/phytoplasma.html

The descriptions and assessment of the diseases of unknown aetiology rely heavily on the Washington State University National Research Support Project website (WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001).

3.2. Organisms and diseases recorded on *Malus*

The viruses, viroids, phytoplasma, bacteria and diseases of unknown aetiology that have been recorded as being associated with *Malus* nursery stock are listed in Appendix 1. Table 1 in Appendix 1 provides a list of the scientific and common names of these organisms, their recorded synonyms and the key references sourced to link these potential hazard organisms with the commodity and the their presence (or not) in New Zealand. Table 3.1 provides the answers to a series of questions that culminates in the decision as to the status of these organisms on the *Malus* nursery stock pathway, either potential hazards or not potential hazards. This table lists a total of 19 viruses, four viroids, three phytoplasma, 34 diseases of unknown aetiology, and five bacteria. Information on the meaning s of the column headings is provided in MAF (2006).

Table 3.1: Potential hazards – Status determination

Scientific name	In NZ?	Vector of a Hazard	In NZ but association with goods increases hazard	In NZ but geographically bounded	In NZ but has different host associations	No or little information on organism	Under official control or notifiable	Potential hazard
Virus[5]								
Apple chlorotic leaf spot virus	Yes	N/A	No	No	No	No	No	No
Apple latent spherical virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple mosaic virus	Yes	N/A	No	No	No	No	No	No
Apple stem grooving virus	Yes	N/A	No	No	No	No	No	No
Apple stem pitting virus	Yes	N/A	No	No	No	No	No	No
Carnation ringspot virus [strains N, A and R]	Yes	N/A	Yes	No	Yes	No	No	Yes
Cherry rasp leaf virus	No	N/A	N/A	N/A	N/A	No	No	Yes
Clover yellow mosaic virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Horseradish latent virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Prunus necrotic ringspot virus	Yes	N/A	No	No	No	No	No	No
Sowbane mosaic virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Tobacco mosaic virus	Yes	N/A	No	No	No	No	No	No
Tobacco necrosis virus (Tobacco necrosis virus A, Tobacco necrosis virus D)	Yes	N/A	No	No	No	No	No	No
Tobacco ringspot virus	Yes	N/A	No	No	No	No	No	No
Tomato bushy stunt virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Tomato ringspot virus (Grape yellow vein strain)	Yes	N/A	No	No	No	No	No	No
Tomato ringspot virus (except Grape yellow vein strain)	No	N/A	No	No	No	No	No	Yes

5 Significant strains are listed separately

Scientific name	In NZ?	Vector of a Hazard	In NZ but association with goods increases hazard	In NZ but geographically bounded	In NZ but has different host associations	No or little information on organism	Under official control or notifiable	Potential hazard
Tulare apple mosaic virus	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Viroids								
Apple dimple fruit viroid	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple fruit crinkle viroid	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple scar skin viroid	No	N/A	N/A	N/A	N/A	No	No	Yes
Peach latent mosaic viroid	No	N/A	N/A	N/A	N/A	No	No	Yes
Phytoplasma								
Candidatus Phytoplasma *asteris*	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Candidatus Phytoplasma *mali*	No	N/A	N/A	N/A	N/A	No	No	Yes
Candidatus Phytoplasma *pyri*	No	N/A	N/A	N/A	N/A	No	No	Yes
Diseases of unknown aetiology								
Apple blister bark agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple brown ringspot agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple bumpy fruit agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple bunchy top agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple chat fruit agent	Yes	N/A	No	No	No	No	No	No
Apple dead spur agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple decline agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple flat limb agent	Yes	N/A	No	No	No	No	No	No
Apple freckle scurf agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple green crinkle agent	Yes	N/A	No	No	No	No	No	No
Apple green dimple and ring blotch agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple junction necrotic pitting agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple leaf chlorosis and fruit distortion agent	Yes	N/A	No	No	No	No	No	No
Apple leaf fleck, bark blister, and fruit distortion agent	Yes	N/A	No	No	No	No	No	No
Apple leaf pucker and fruit russet agent	Yes	N/A	No	No	No	No	No	No
Apple McIntosh depression agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple narrow leaf agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple necrosis agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple necrotic spot & mottle agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple Newton wrinkle agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple painted face agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes

Scientific name	In NZ?	Vector of a Hazard	In NZ but association with goods increases hazard	In NZ but geographically bounded	In NZ but has different host associations	No or little information on organism	Under official control or notifiable	Potential hazard
Apple platycarpa dwarf agent	Yes	N/A	No	No	No	No	No	No
Apple platycarpa scaly bark agent	Yes	N/A	No	No	No	No	No	No
Apple pustule canker agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple red ring agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Apple ringspot agent	Yes	N/A	No	No	No	No	No	No
Apple rosette agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple rough skin agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple rubbery wood agent	Yes	N/A	No	No	No	No	No	No
Apple russet ring agent	Yes	N/A	No	No	No	No	No	No
Apple russet wart agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple star crack agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Apple transmissible internal bark necrosis agent	No	N/A	N/A	N/A	N/A	No	No	Yes
Quince yellow mosaic agent	No	N/A	N/A	N/A	N/A	Yes	No	Yes
Bacteria								
Erwinia amylovora	Yes	No	No	No	No	No	No	No
Pseudomonas cichorii	Yes	No	No	No	No	No	No	No
Pseudomonas syringae pv. *papulans*	No	No	N/A	N/A	N/A	No	No	Yes
Pseudomonas syringae pv. *syringae*	Yes	No	No	No	No	No	No	No
Rhizobium radiobacter	Yes	No	No	No	No	No	No	No

3.3. References for chapter 3

Agrios G N (2005) Plant pathology. Fifth Edition. *Academic Press* inc, pp 801

Bokx, de J A; Want, van der J P H (1987) Viruses of potatoes and seed-potato production. 2nd edition. Pudoc Wageningen, pp 259

Brunt, A.A., Crabtree, K., Dallwitz, M.J., Gibbs, A.J., Watson, L. and Zurcher, E.J. (eds.) (1996). Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996. Available at: http://image.fs.uidaho.edu/vide/

Constable, F; Rodoni, B; Joyce, P (2006) Improving diagnostic protocols to ensure rapid and safe access to imported pome fruit propagating germplasm. Final report for Horticulture Australia project AP01030. Department of Primary Industries Knoxfield, pp 161

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses.* Elsevier Academic Press, London, UK; 1259 pp.

MAF (2006) Biosecurity New Zealand risk analysis procedures. Ministry of Agriculture and Forestry, New Zealand, 201 pp. Available online at http://www.biosecurity.govt.nz/files/pests-diseases/surveillance-review/risk-analysis-procedures.pdf

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001

4. General phytosanitary measures for nursery stock

The following section provides information on a number of general phytosanitary measures that may be considered prior to biosecurity clearance on all *Malus* nursery stock imported into New Zealand. These general requirements are designed both to limit the likely level of contamination of the imported material at the beginning of the quarantine period, and improve the expression of symptoms of any hazard organisms that might be present.

4.1. Important generic risk factors

The following pathway and risk characteristics are generic to the consideration of the biosecurity risks of the identified potential hazards.

4.1.1. Potential volume of trade

When considering likely options for phytosanitary measures to mitigate, to an acceptable level, the risks represented by the various hazard organisms potentially associated with *Malus* nursery stock in international trade, the volume of that trade is an important consideration. The majority of measures applied to manage biosecurity risk prior to and on arrival in New Zealand are aimed at reducing the likelihood of the risk occurring rather than attempting to directly reduce the magnitude of any consequences of risks being realised. Volume of trade, and therefore the frequency of a risk event over a period of trading, is directly proportional to the likelihood of the event occurring. The single period of trade used is one year (annual trade) unless biological factors warrant consideration of shorter or longer periods.

Given the relatively high costs associated with testing and inspecting *Malus* nursery stock for clearance into New Zealand under the current standard, the volume of traded material in any one year is unlikely to exceed 100 plants. This risk analysis will therefore assume that as a worst case no more than 100 plants will be imported in any one year.

4.2. Collection, handling and storage of budwood

Budsticks should be not more than one year old at the time of collection to limit the likelihood of contamination by pathogenic (quarantine) fungi. Budsticks should not be collected from mother plants showing any signs of disease disorders. All tools used in the collection and handling of plant material for export to New Zealand should, before coming in contact with any new material (i.e. each new tree), be cleaned of any visible plant contamination and dipped in a solution of 1% (available chlorine) Sodium hypochlorite (NaOCl).

Cold storage of budwood has two main uses:

1. To give the budding operator more flexibility with labour availability and weather conditions after the budwood has been collected. This can be described as short-term storage.
2. The collection of ripened wood for spring-chip budding the following season. This is described as long-term cold storage.

The recommended procedure for storage of budwood for spring chip budding is to collect healthy ripened shoots late in the season, place the bundles in a sealed polyethylene bag with a few drops of water adhering to the inner surface, and then place into a cold storage facility at 1^{o}C (34^{o}F). Should a jacketed (indirect) cold storage facility with very high humidity be available, the budwood is left unwrapped and placed on an open shelf in the store at -1 to 0^{o}C (30-32^{o}F). Above these temperatures there is a likelihood that the bud will swell and break while in storage, especially after six months. High temperatures also mean that there is more danger of losses from disease infection. The signs of budwood deterioration are shrivelling of the stem and blackening of the tissue, particularly around the bud (Macdonald 1986).

Budwood of *Malus* can be sourced from open ground or enclosed nursery areas. To comply with New Zealand's existing import requirements for soil, plants would need to be prepared for export to New Zealand by removing all visible soil.

Budsticks should be disinfected prior to budding onto rootstocks and commencing quarantine by one of the following two methods:

- Methyl bromide fumigation, for the disinfestation of any surface-dwelling invertebrates.
- Sodium hypochlorite dip, for the removal of surface micro-organism contamination such as by fungi, nematodes and bacteria.

4.2.1. Methyl bromide fumigation

The following methyl bromide treatment schedule (Table 5.1) has been derived from schedules for surface insects provided in the FAO Manual of Fumigation Control (Bond 1984) and the USDA Treatment Manual (Davis & Venette 2004). The actual level of efficacy of this treatment against all but a few insect species has yet to be determined with any accuracy.

Table 5.1: Methyl bromide fumigation schedule for surface feeding insect infestations (foliated dormant plants under atmospheric conditions).

Rate (g/m^3)	Temperature (^OC)	Treatment Duration (hours)	C/T Value ($g\ h/m^3$)
64 g/m^3	4 to 10^OC	3	114
64 g/m^3	11 to 15^OC	2.5	102
64 g/m^3	16 to 20^OC	2	90
48 g/m^3	21 to 25^OC	2	76
40 g/m^3	26 to 29^OC	2	56
32 g/m^3	30 to 32^OC	2.5	48

At the time of completing this analysis the level of phytotoxicity of methyl bromide against *Malus* nursery stock was unknown. However it should be recognised that methyl bromide treatments have been used on apple budwood for many years. Care should be taken to ensure phytotoxicity levels are acceptable before applying any chemical treatments to plant material.

4.2.2. Dip in a sterilising solution

Immerse for a short time in a sterilising solution such as sodium hypochlorite (NaOCl) or chlorobromohydantoin (BCDMH). To optimise the effectiveness of this treatment the material should be clean. A surfactant may be required to ensure adequate surface contact and the solutions must be buffered to an appropriate pH.

4.3. Disease symptom expression and testing

The following section describes conditions for optimal disease expression of the various types of diseases potentially present on imported *Malus* nursery stock.

4.3.1. Viruses

Options for specific testing protocols for hazard viruses are provided in the following chapters where appropriate. Ideally testing protocols should be supported by information that provides a degree of confidence (normally 95%) that a specified level of sensitivity and specificity would be achieved. The sensitivity level of a test indicates the likelihood that any contamination will be detected while the specificity level provides information on false positives that may occur when other virus or virus-like material is present.

Diseases causing symptoms on fruit or bark may take up to 3 years to express symptoms. However, infection does not always lead to symptom expression. It is important to include adequate positive (where possible) and negative controls in each test to distinguish viral symptoms from other factors. Sampling procedures will need to address issues with irregular or localised distribution of viruses. Specific climatic conditions may be required for symptom expression in some cases. Mixed infections can mask the symptoms of one or more viruses (CFIA-ACIA 2005a, CFIA-ACIA 2005b).

In the absence of information on sensitivity and specificity it will be assumed in this risk analysis that, in the absence of factors that may render tests ineffective such as low titre or localised infections, tests will provide (at 95% confidence) at least a 90% level of sensitivity. A 90% level of sensitivity would mean that should 10 infected plants be imported for testing there would be a 95% chance that one of those plants would be falsely tested negative. Should a second test be undertaken there would be a 95% chance that only one plant in 100 would provide a false negative result. As the volume of consignments of *Malus* nursery stock is likely to be low (see section 5.1.1 for further discussion on likely volumes), dual testing providing a 95% confidence of detecting 99% of infected material would seem to be a more than adequate level of sensitivity for this pathway. The level of test specificity is less important as false positives will need to be tested further before release to confirm the nature of the infestation.

A number of hazard viruses do not yet have specific testing protocols available. Detection of these and other new-to-science viruses will rely on symptom expression on the mother plants and any indicator plants that have been inoculated, and the non-specific detection of virus material during PCR, ELISA or other tests for specific hazard viruses.

4.3.2. Viroids

Options for specific testing protocols for hazard viroids are provided in the following chapters where appropriate. In general high light intensities as well as temperatures of 26-29°C are optimal for viroid disease symptom development while high light intensities and temperatures between 22-26°C favour the build-up of extractable viroid RNA (Handley & Horst 1988). Incubation periods for symptom expression can be as long as three months, so periods of relatively high (>10,000 lux) daytime light intensity and temperatures should run for at least 120 days.

As with tests for viruses, it will be assumed in this risk analysis that tests will provide (at 95% confidence) at least a 90% level of sensitivity and therefore dual testing providing a 95% confidence of detecting 99% of infected material would seem to be a more than adequate level of sensitivity for this pathway.

4.3.3. Phytoplasma

There are a number of phytoplasmas known to be associated with *Malus* nursery stock, and specific tests for a few of these have been provided in the following chapters. An option for improving the likelihood of detecting these known phytoplasmas and potentially any new-to-science phytoplasmas that may also be present, is the use of a universal PCR test for phytoplasmas. There are a number of examples of universal primers available in the literature that could be considered appropriate for use on *Malus* nursery stock.

At the time of preparing this risk analysis no information was available on the sensitivity of universal PCR testing. Known difficulties with these tests occur in association with low phytoplasma titre, seasonal fluctuations in phytoplasma infection, or uneven distribution of some phytoplasmas within their host plants (Postman pers. com. 2008).

4.3.4. Diseases of unknown aetiology

The causal agent of these diseases is, by definition, unknown, so detection and identification must rely on visual inspection of the mother plants or through grafting onto plants that are known to be susceptible. Options for specific requirements for inspection are included in the following chapter related to these diseases, but in general inspections should occur at all stages of growth. Freedom from common graft- or mechanically-transmitted pathogens might indicate a reduced risk of certain diseases of unknown aetiology (Postman pers. com. 2008).

To enhance the likelihood of disease expression during woody indexing, plant material being prepared for quarantine should be allowed to go through a natural winter dormancy period with adequate chilling (BA 2002). Testing should involve a period of heat stress to improve symptom expression, and should occur over a minimum of two growing seasons.

4.3.5. Bacteria and fungi

Symptom expression of diseases caused by many hazard bacteria is enhanced in higher temperature and humidity levels. At a minimum over the summer and autumn periods, temperatures in quarantine should be kept above 18.5ºC and the growing area misted or watered from overhead to maintain a relatively high humidity. Temperatures may need to be lowered during winter to enhance viral symptom expression in spring. Plants should not be routinely sprayed with fungicides or bactericides as these may suppress or mask disease expression and are unlikely to decontaminate the plant material. Any fungicides or bactericides used to maintain plant health should have relatively short persistence periods in plant or spoil material e.g. a few weeks only.

4.3.6. General plant health and containment requirements

There are a number of general plant health and containment requirements that may be taken into account when considering the handling, growing and inspection of imported *Malus* nursery stock in the country of origin or while in post entry quarantine in New Zealand. These requirements include:

- As a general rule nursery stock and/or indexed material should be inspected over two growing seasons unless specific tests warrant reduced inspection periods.
- Unless stated otherwise, all imported nursery stock (each plant) should be regularly inspected each growing season for disease symptoms.
- All parts (leaves, stems and roots) of each import plant should be inspected for disease symptoms, even when bud stocks have been grafted onto local rootstocks.
- Environmental conditions should, where possible, be manipulated to enhance disease symptom expression, including exposing the imported nursery stock to heat and water stress, and variable temperature and day length conditions.
- Containment conditions should be sufficient to both limit the likelihood of hazard organisms escaping the facility and limit the ability of local organisms to vector hazard organisms from the imported plants and into the local environment (in New Zealand) or from the local environment on to the material to be exported (country of origin). The level of security provided by the facility should therefore be sufficient to contain such propagules as airborne fungal spores, pollen, and vector insects. Currently the only measures known to provide this level of containment are to ensure all outward flowing air vents are filtered with a High-Efficiency Particulate Air (HEPA) filter, and a negative air pressure (15 Pa) is

maintained within the facility. MAF recognises the likely costs associated with such measures may not be cost-effective and will review potential alternatives to managing this identified risk.

- As many plant diseases can be mechanically transmitted between host plants, plants in containment should be kept separate to ensure that no parts of the plant are exposed to other plants. Phytosanitary measures may also need to be taken to limit pollen development and/or spread.
- All waste plant material should be destroyed by incineration or deep burial.

The phytosanitary measures described above are designed to enhance the level of protection achieved during the import of *Malus* nursery stock into New Zealand. The level of effectiveness of each phytosanitary measure will reflect the conditions and circumstances of their application.

4.3.7. Generally applicable phytosanitary measures options

This chapter provides some general information about options that may be available to manage any risks that are considered of sufficient concern to require mitigation. As the nature and strength of any phytosanitary measures will need to reflect the nature and strength of the identified risks, actual mitigation options will be discussed within the risk management sections of each hazard risk analysis chapter.

Phytosanitary measures may be considered by themselves or in combination with other phytosanitary measures as part of a systems approach to mitigate risk.

4.3.7.1. Pest free area (PFA)

The International Standards for Phytosanitary Measures number 4: *Requirements for the establishment of pest free areas* (FAO 1995) describes the requirements for the establishment and use of PFAs as a risk management option for meeting phytosanitary requirements for the import of plants. The standard identifies three main components or stages that must be considered in the establishment and subsequent maintenance of a PFA:

- systems to establish freedom
- phytosanitary measures to maintain freedom
- checks to verify freedom has been maintained.

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. It is accepted internationally that organisms or diseases that have never been detected in, or that have been detected and eradicated from, and area should not be considered present in an area if there has been sufficient opportunity for them to have been detected.

When sufficient information is available to support a PFA declaration, this phytosanitary measure is usually considered to provide a very high level of protection.

4.3.7.2. Pest free place of production (PFPP)

The International Standards for Phytosanitary Measures number 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 1999) describes the requirements for the establishment and use of pest free places of production as a risk management option for meeting phytosanitary requirements for the import of plants. A pest free place of production is defined in the standard as a “place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period”. Pest freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the place of production.

When sufficient information is available to support a PFPP declaration, this phytosanitary measure is usually considered to provide a high level of protection depending on the epidemiological characteristics of the organism or disease in question.

4.3.7.3. Risk mitigation by industry

Spread of diseases that are only graft transmittable and very restricted in host range, can be easily managed by industry simply through the removal of any contaminated lines. Infected material imported for research and development are less likely to result in significant impacts, as disease impacts would be resolved before any material is made available for commercial distribution. Information about host range for diseases on unknown aetiology, however, is limited as the disease description is based on symptoms rather than causal organism and it is common for a pathogen to cause different symptoms in different hosts. Until the cause of a disease is known the host range description cannot be considered reliable. That being said, diseases that are truly only mechanically and/or graft transmissible are unlikely to spread naturally between different host species.

In instances where diseases are recorded as being mechanically and/or graft transmissible only, and the host range is restricted to the imported plant species or genus, industry may choose to assume the responsibility for managing the biosecurity risks without official controls. The affected industries are acting as both risk exacerbators (they cause the risk by importing the material) and risk bearers (they will suffer any consequences from lost productivity or market access). This risk analysis will identify where these instances may exist and provide as an option the opportunity for industry to manage the risks without official controls.

4.4. References for chapter 4

BA (2002) Biosecurity Australia. Review of Post-Entry Quarantine Protocols for the Importation into Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. (February 2002). *Commonwealth Department of Agriculture, Fisheries and Forestry, Australia*; pp 68.

CFIA-ACIA (2005a) Virus testing of *Malus* spp. by woody host bioassay. Centre for Plant Health, *Canadian Food Inspection Agency*; pp 17.

CFIA-ACIA (2005b) Herbaceous bioassay for the detection of viruses in fruit trees, grapevines and other crops. Centre for Plant Health, *Canadian Food Inspection Agency*; pp 21.

Davis E E, Venette R C (2004) Methyl bromide provides phytosanitary security: a review and case study for Senegalese asparagus. *Plant Health Progress* (November): 1-6.

Bond E J (1984) Manual of fumigation for insect control. *FAO Plant Production and Protection Paper* 54; pp. : Available at www.fao.org/docrep/X5042E/x5042E0t.htm

Handley M K, Horst R K (1988) The effect of temperature and light on chrysanthemum stunt viroid infection of florist's chrysanthemum. *Acta Horticulturae* 234, pp. 89-97.

FAO (1995) ISPM No. 4: Requirements for the establishment of pest free areas. FAO. Available at https://www.ippc.int/IPP/En/default.jsp

FAO (1999) ISPM No. 10: Requirements for the establishment of pest free places of production and pest free production sites. FAO. Available at https://www.ippc.int/IPP/En/default.jsp

Macdonald B (1986) Practical Woody Plant Propagation for Nursery Growers: Volume 1. *Timber Press*, 660 pages.

Postman D pers. com. (2008) Comments made during expert scientific review of a draft IRA for *Malus* nursery stock by Dan Postman, in personal communication with R.R. Martin, USDA/ARS, Corvallis, Oregon; Parm Randawa, California Seed & Plant Lab; and Bruce Kirkpatrick, University of California, Davis.

5. Risk analyses – Viruses

5.1. Apple latent spherical virus (ALSV)

5.1.1. Hazard identification

5.1.1.1. Aetiologic agent

Apple latent spherical virus (ALSV) (ICTVdB Management 2006). Li *et al.* 2000 classified the virus into the family Comoviridae. However, Fauquet *et al.* 2005 more recently listed it as genus *Cheravirus* with the family unassigned.

5.1.1.2. New Zealand status

ALSV has not been recorded in New Zealand (Pearson *et al* 2006, PPIN 2009).

5.1.1.3. Biology and epidemiology

There is very little information available on ALSV. The virus was originally isolated from an apple tree (*Malus domestica* cv. Indo which had been grafted with *M. domestica* cv. Fuji) in Japan that had been showing fruit russet ring symptoms. Laboratory host range testing found systematic infection of *Chenopodium quinoa* and *Tetragonia expansa* which showed symptoms such as leaf mottling, and *Chenopodium amaranticolor* and *Beta vulgaris* which were symptomless (Li *et al.* 2000).

Based on the descriptions of this virus provided by Li *et al.* 2000, and a general understanding of research work in viruses of *Malus*, the following assumptions are proposed:

1. Because *Malus* is a high value crop worldwide, *Malus* and *Malus* diseases are generally well studied. The lack of information on ALSV epidemiology suggests that this virus has had little impact worldwide. It is possible however that this virus may have been found causing damage in a country that does not value apples (and so would not investigate and/or report), found on a cultivar or species of *Malus* that is relatively resistant, or the symptoms may have been confused with other virus diseases of apple. *Cherry rasp leaf virus* (CRLV), the type species for the virus genus *Cheravirus*, is also found in apple and may have masked detection of ALSV (Index of Viruses – Cheravirus 2006).

2. The word “latent”, which describes a condition that is present but not active or causing symptoms, is used as a descriptor. However “latent” viruses do often show symptoms when the plants are stressed, and may be important on other hosts.

While there is no other information available on ALSV, the other (type) member of the genus *Cheravirus*, CRLV, is transmitted by nematodes (*Xiphinema americanum*) in the field (ICTVdB Management 2006). *Xiphinema americanum* has been recorded in New Zealand (PPIN 2009).

Geographic distribution

This is unclear but Li *et al*. (2000) considers ALSV is present in Japan and may be more widely distributed in Asia.

5.1.1.4. Hazard identification conclusion

The lack of information on the nature and effects of this virus requires us to consider it a potential hazard requiring further assessment.

5.1.2. Risk assessment

5.1.2.1. Entry assessment

There is very little information available about the distribution or occurrence of this virus internationally (hosts or regions). This may in part be due to the lack of symptoms of this virus in the cultivars or species of *Malus* it has been detected and the similarity between observed symptoms and those of other apple diseases.

Given the lack of information the likelihood of entry should be considered non-negligible.

5.1.2.2. Assessment of exposure and establishment

Should this virus be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.1.2.3. Consequence assessment

Spread

There is little information on how ALSV is distributed within a population of host plants. The other member of the genus *Cheravirus*, CRLV, is transmitted in the field by nematodes (*Xiphinema americanum*) (ICTVdB Management 2006). There is therefore a low likelihood that ALSV will be able to spread through host plant populations relatively easily. ALSV is likely to be difficult to remove once it has become established and has spread.

Economic consequences

There is little information available on the impacts of ALSV on the cultivars used in horticulture in New Zealand. Should the virus produce significant disease effects on important cultivars in New Zealand the economic impact would be expected to be limited to production only, with market access (exports) unaffected beyond potential supply issues. As such there is considered only a low likelihood that economic consequences will be low on susceptible cultivars in New Zealand.

Environmental consequences

As most plant viruses are relatively host specific and there are no *Malus* species in the New Zealand indigenous flora, it is considered unlikely that ALSV will have an impact on native flora. *Malus* species are common in New Zealand's urban areas and ALSV could potentially impact both environmentally and economically in this type of environment through, for example, reducing apple yields.

Human health consequences

There are no significant human health consequences expected from ALSV.

5.1.2.4. Conclusion of consequence assessment

Based on the above assessment it is concluded that ALSV, on susceptible cultivars in private gardens or commercial apple-growing orchards, has a low likelihood of causing low economic or environmental consequences to New Zealand.

5.1.2.5. Risk estimation

The risk of ALSV being introduced into New Zealand with *Malus* budwood and causing unwanted impacts is considered non-negligible mainly due to the lack of available epidemiological information to show otherwise. However, the above risk estimation is subject to review when further information on distribution, biology and potential impact becomes available.

5.1.2.6. Assessment of uncertainty

There is considerable uncertainty around the taxonomy, biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.1.3. Risk management

5.1.3.1. Risk evaluation

Since the risk estimate for ALSV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.1.3.2. Option evaluation

There are conceivably a number of management options available for ALSV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ALSV;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ALSV;
- **d.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

The level of assessed risk from ALSV is non-negligible mainly due to the lack of available information on this disease agent. This risk analysis recognises that given the level of uncertainty around the epidemiology of ALSV the low level of associated biosecurity risk may be considered acceptable.

Pest free area (PFA)

Given the paucity of information available on the epidemiology of ALSV it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFA determination could be obtained. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

Given the paucity of information available on the epidemiology of ALSV it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus and knowledge of potential vectors, a suitably reliable PFA determination could be obtained under most circumstances.

Virus indexing of mother plants

While there is no specific virus indexing method documented for ALSV, mechanical inoculation tests from the mother plants onto susceptible host material such as *Chenopodium quinoa* should ensure disease symptoms become apparent. Inoculation of herbaceous indicators followed by ELISA or PCR testing (if available) of symptomatic material should be used to confirm the identity of the causal agent as ALSV.

There is currently no information on the reliability of mechanical inoculation of ALSV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test schedule described here should be considered an effective phytosanitary measure against ALSV (see section 4.3.1 for more discussion).

Inspection of mother plants

Relying on the detection of ALSV infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against ALSV.

5.1.4. References

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses.* Elsevier Academic Press, London, UK; 1259 pp.

ICTVdB Management (2006) 00.111.0.01.001. Cherry rasp leaf virus. In: *ICTVdB - The Universal Virus Database,* version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA. http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.111.0.01.001.htm

Index of Viruses - Cheravirus (2006) In: ICTVdB - The Universal Virus Database, version 4. Büchen-Osmond, C (Ed), Columbia University, New York, USA. http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/

Li C; Yoshikawa, N; Takahashi, T; Ito, T; Yoshida, K; Koganezawa, H (2000) Nucleotide sequence and genome organization of apple latent spherical virus: a new virus classified into the family Comoviridae. *Journal of General Virology* 81(2): 541-547.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

5.2. Carnation ringspot virus (CRSV)

5.2.1. Hazard identification

5.2.1.1. Aetiologic agent

Carnation ringspot virus (CRSV), Family; Tombusviridae, Genus; *Dianthovirus* (Brunt *et al*. 1996, ICTVdB Management 2006)

5.2.1.2. New Zealand status

CRSV has been reported in New Zealand only on carnation (*Dianthus caryophyllus*) in Pennycook (1989) and Pearson *et al*. (2006). While CRSV appears to be endemic in stone fruits in Eastern and Central Europe, it has not been reported in stone fruits or grapes in any other parts of the world (CPC 2007). Tremaine & Ronald (1976) recorded three strains of CRSV based on aggregation properties, namely N, A and R. No information could be found describing the aggregation properties CRSV in New Zealand.

5.2.1.3. Biology and epidemiology

CRSV is an established and persistent problem in commercial carnation facilities (CPC 2007). Carnations infected with CRSV alone, or in combination with any of several other viruses, yield low quality unmarketable flowers (CPC 2007). CRSV infection in carnations results in diagnostic ring spots, mottling and leaf and flower distortions. In severe infections, or in susceptible carnation cultivars, leaf tip necrosis can also occur. In general, CRSV infections do not kill the host plants; however, necrosis and symptom severity can become quite severe at sustained temperatures between 15 and 20°C compared with temperatures above 20°C (Brunt *et al*. 1996, CPC 2007).

CRSV symptoms in stone fruits and other orchard crops appear to be mild and difficult to discern. CRSV symptom determination is further complicated by the fact that most CRSV infected trees and vines are infected with one or more other diseases. For example, in situations where CRSV was detected in apple, the trees were also infected with apple Spy decline (synonym of Apple Stem Pitting Virus) or pear red mottle. Unfortunately, the titre of CRSV in orchard trees is exceedingly low, making transmission studies and the accomplishment of Koch's postulates very difficult (CPC 2007). On experimental systemic hosts, CRSV causes concentric ringspots with necrotic centres on the inoculated leaves and mosaics, necrotic flecks and veinal necrosis on the systemically infected leaves (Brunt *et al*. 1996, CPC 2007). CRSV is also reported to cause a disease termed “stony pit” in pear (Richter *et al*. 1978) and decline diseases in sour cherry and apple (Kleinhempel *et al*. 1980).

Dianthoviruses are not transmitted through seed, by insects or by soil inhabiting fungi. However, confusion exists as to whether Dianthoviruses can be transmitted from plant-to-plant by nematodes (Brunt *et al*. 1996, CPC 2007). Early reports suggested that CRSV could be transmitted by several species of nematodes including *Longidorus elongatus*, *L. macrosoma*, and *Xiphinema diversicaudatum*. These data tended to confirm observations that CRSV infections were more widely spread in orchards and vineyards when the soil was infested with known virus-vectoring nematodes (Kleinhempel *et al*. 1980). However, more recent reports suggest that CRSV particles are released directly from infected roots into the soil (CPC 2007, Kegler *et al.* 1983, Koenig *et al.* 1989). Plant-to-plant transmission can then occur passively through the soil in the absence of a biological vector (CPC 2007). Presumably, infection occurs through root wounds. Nematode and soil fungus colonization of roots tends to increase the possibility of soil transmission of Dianthoviruses by generating virus entry sites, but transmission is not dependent on this. Thus, Dianthoviruses require no biological vector for soil transmission (CPC 2007, Kegler *et al.* 1983). Dianthoviruses are readily mechanically transmissible. In nature, Dianthoviruses are transmitted from plant-to-plant by physical contact or by contaminated soil. In addition, CRSV spread in carnations is most likely due to vegetative propagation (CPC 2007).

Hosts

CRSV has a moderately broad natural and experimental host range. It has been experimentally transmitted to 133 species in 25 families (CPC 2007, Kegler *et al.* 1983). Recorded natural hosts of CRSV include *Dianthus* (carnation), *Dianthus barbatus* (sweet williams), *Dianthus caryophyllus* (carnation), *Malus sylvestris* (crab-apple tree), *Prunus avium* (sweet cherry), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Pyrus communis* (European pear) *Vitis vinifera* (grapevine), *Poa annua* (annual meadowgrass), *Stellaria media* (common chickweed), and *Urtica urens* (annual nettle) (CPC 2007, Kegler *et al.* 1983).

In Eastern and Central Europe, CRSV infects a wide range of orchard and vine crops. It was detected in trees of different apple, pear and sour cherry varieties by mechanical transmissions to herbaceous host plants and by ELISA-tests (Kleinhempel *et al*. 1980). Kleinhempel *et al*. 1980 noted that viral isolates from fruit trees did not differ significantly from a carnation isolate in their biological (symptoms on indicator plants), physical (thermal inactivation point, dilution end point, longevity *in vitro*, molecular weight) and serological (Ouchterlony double diffusion test) properties (Kleinhempel *et al*. 1980, Richter *et al*. 1978). Aggregation tests on CRSV, completed for taxonomic reasons using heat (Tremaine *et al.* 1984), sodium dodecyl sulphate (SDS) (Dodds *et al.* 1977, Tremaine & Ronald 1976), sodium dextran sulphate (NDS) (Tremaine *et al.* 1983), and other chemicals and pH levels (Tremaine & Ronald 1985), identified three strains of the virus isolated from a single lesion (Tremaine & Ronald 1976). The strains were designated CRSV-N, a non-aggregating strain; CRSV-A, a strain forming aggregates of 12 virus particles; and CRSV-R, a strain showing reversible, temperature-dependent aggregation (Tremaine & Ronald 1976).

Measuring biological, physical or serological properties may not have been sensitive enough to detect strain differences. It is also possible that the European strain or isolate of CRSV infects both fruit trees and carnation (and as such the same variant was tested) while the strain or isolate in New Zealand and other countries is carnation specific. No papers could be found that indicate that CRSV isolates extracted from carnation plants can infect fruit trees in New Zealand or other countries.

The economic impact of CRSV on stone fruit and other orchard crops in Central Europe is uncertain. No studies determining the effects of CRSV in the absence of other viruses on these hosts have been performed (CPC 2007). CRSV occurred at varying frequency in weeds growing in orchards and was detected in soil solutions (CPC 2007, Kegler *et al.* 1983).

Geographic distribution

CRSV has been identified wherever carnations are grown on a large scale. The worldwide distribution of CRSV is most likely due to the practice of distributing vegetative propagules within the floral industry. Quite separately, CRSV is also established in stone fruit and grape orchards in Eastern and Central Europe (CPC 2007). CRSV has been found, but with no evidence of spread, in Australia (Brunt *et al*. 1996, ICTVdB Management 2006).

5.2.1.4. Hazard identification conclusion

As CRSV has never been recorded on *Malus* in New Zealand even though the virus is present, widespread, and the necessary vector(s) (if required) are present, for the purposes of this assessment it will be assumed that any CRSV imported on *Malus* nursery stock is a separate strain or variant from the CRSV recorded in New Zealand on carnation.

Therefore accepted absence of CRSV on *Malus* in New Zealand, the ability of this virus to be vectored by *Malus* nursery stock in international trade, and its potential ability to cause disease symptoms on commercial plants in New Zealand (other than on those it is already found) all suggest that CRSV should be considered a potential hazard requiring further assessment.

5.2.2. Risk assessment

5.2.2.1. Entry assessment

While there is some information about the distribution of CRSV internationally there is little information about the persistence of the virus in infected *Malus* populations. However as with any virus, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of CRSV into New Zealand with *Malus* nursery stock is non-negligible.

5.2.2.2. Assessment of exposure and establishment

Should CRSV be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.2.2.3. Consequence assessment

Spread

As the transmission of CRSV is likely to be assisted by soil nematodes; is known to be transmitted by mechanical inoculation and grafting; and has a relatively wide range of hosts and potential hosts; it should be expected that the virus would spread rapidly through the New Zealand environment.

Economic consequences

CRSV symptoms in stone fruits and other orchard crops in commercial production are difficult to discern separately from other diseases present on the trees. On experimental systemic hosts, CRSV causes concentric ringspots with necrotic centres on the inoculated leaves and mosaics, necrotic flecks and veinal necrosis on the systemically infected leaves (ICTVdB Management 2006, CPC 2007). Should the virus produce significant disease effects on important cultivars in New Zealand, the economic impact would be to effects on production and to a lesser extent market access for germplasm (as CRSV is regulated by a number of our major trading partners). The potential economic impact of CRSV on the New Zealand agricultural sector should therefore be considered to have a low likelihood of being low to moderate.

Environmental consequences

A number of weed species are reported to hosts of CRSV and can be found growing in and around orchards and gardens. These hosts may act as reservoir hosts for the virus to spread onto more important environmental or ecological hosts. While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by CRSV, namely localised leaf necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by CRSV lowering fruit yield or quality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of CRSV in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

CRSV is not known to be of any significance to human health.

5.2.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that CRSV has a moderate likelihood of causing low to moderate unwanted economic consequences and a low likelihood of causing low environmental consequences to New Zealand.

5.2.2.5. Risk estimation

The likelihood estimate is low that CRSV would be associated with *Malus* nursery stock on entry into New Zealand, high that any CRSV that does enter would successfully establish in New Zealand, low that the establishment would result in low to moderate unwanted economic consequences and low environmental consequences in New Zealand. As a result the risk estimate for CRSV associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

5.2.2.6. Assessment of uncertainty

There is considerable uncertainty around the taxonomy, biology, distribution and epidemiology of potential strains of CRSV. As such this risk assessment should be reviewed once further relevant information becomes available.

5.2.3. Risk management

5.2.3.1. Risk evaluation

Since the risk estimate for CRSV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.2.3.2. Option evaluation

There are conceivably a number of management options available for CRSV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of CRSV;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of CRSV;
- **c.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

Given the paucity of information available on the epidemiology of CRSV on *Malus* it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus on *Malus*, a reliable PFA determination could be obtained. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

Given the paucity of information available on the epidemiology of CRSV on *Malus* it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFPP determination could be obtained.

Virus indexing of mother plants

Of the six to eight major viruses of carnations, CRSV is the only one that produces highly diagnostic and reproducible concentric necrotic ringspots on several diagnostic hosts including *Dianthus barbatus*, *Gomphrena globosa* and *Nicotiana clevelandii*. Other diagnostic hosts include *Chenopodium amaranticolor*, *C. quinoa*, *Tetragonia tetragonioides* or *Vigna unguiculata*. Inoculation of one of these herbaceous indicators can be followed by one of several formats of ELISA that have been developed and are effective in identifying CRSV (CPC 2007, Lommel *et al.* 1983).

There is currently no information on the reliability of mechanical inoculation of CRSV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test indexing schedule should be considered an effective phytosanitary measure against CRSV (see section 4.3.1 for more discussion).

Inspection of mother plants

Relying on the detection of CRSV infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against CRSV.

5.2.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Brunt A A, Crabtree K, Dallwitz M J, Gibbs A J, Watson L, Zurcher E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*. Available at: http://image.fs.uidaho.edu/vide/

CPC (2007) *Crop Protection Compendium on Internet.* CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Dodds J A, Tremaine J H, Ronald W P (1977) Some properties of carnation ringspot virus single- and double-stranded ribonucleic acid. *Virology* 83: pgs 322-328.

ICTVdB Management (2006). 00.074.0.04.001. Carnation ringspot virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA; http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.074.0.04.001.htm

Kegler H, Kegler G, Kleinhempel H (1983) Epidemiological investigations on carnation ringspot virus and tomato bushy stunt virus in fruit orchards. *Zeszyty Problemowe Postepów Nauk Rolniczych* 291: pgs 155-162.

Kleinhempel H, Gruber G, Kegler H (1980) Investigations on carnation ringspot virus in fruit trees. *XI International Symposium on Fruit Tree Virus Diseases*. *Acta Horticulturae* (ISHS) 94: pgs 107-112

Koenig R, Rüdel M, Lesemann D E (1989) Detection of petunia asteroid mosaic, carnation ringspot and tobacco necrosis viruses in ditches and drainage canals in a grapevine-growing area in West Germany. *Journal of Phytopathology* 127: pgs 169-172.

Lommel S A, McCain A H, Mayhew D E, Morris T J (1983) Survey of commercial carnation cultivars for four viruses in California by indirect enzyme-linked immunosorbent assay. *Plant Disease* 67: pgs 53-56.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35 (2): 217-252

Pennycook, S R (1989) *Plant diseases recorded in New Zealand.* Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

Richter J, Kleinhempel H, Gruber G, Kegler H (1978) Identification of a virus in pears with stony pit as carnation ringspot virus. *Archiv fur Phytopathologie und Pflanzenschutz* 14: pgs 411-412.

Tremaine J H, Ronald W P (1976) Differential effects of sodium dodecyl sulphate on strains of carnation ringspot virus. *J. gen. Virol.* 30: pgs 299-308.

Tremaine J H, Ronald W P (1985) The effect of pH and some selected chemicals on the temperature-reversible aggregation of carnation ringspot virus. *Phytopathology* 75: 467-471.

Tremaine J H, Ronald W P, Valcic A (1976) Aggregation properties of carnation ringspot virus. *Phytopathology* 66: pgs 34-39.

Tremaine J H, Ronald W P, McGauley E M (1983) Effect of sodium dextran sulfate on some isometric plant viruses. *Phytopathology* 73: pgs 1241-1246.

Tremaine J H, Ronald W P, McGauley E M (1984) Temperature-reversible aggregation of two strains of carnation ringspot virus. *Phytopathology* 74: pgs 161-165.

5.3. Cherry rasp leaf virus (CRLV)

5.3.1. Hazard identification

5.3.1.1. Aetiologic agent

Cherry rasp leaf virus (CRLV) (Stace-Smith & Hansen, 1976a, b; Wellinck *et al*. 2000; ICTVdB Management 2006) is listed by Fauquet *et al.* (2005) as genus *Cheravirus* with the family unassigned. Wellinck *et al*. (2000) and others had previously listed CRLV as a tentative member of the *Nepovirus* genus.

5.3.1.2. New Zealand status

CRLV was reported on cherry, sweet cherry and *Prunus avium* in Pennycook (1989). A rasp leaf disease of cherry occurring in New Zealand was reported by Helson (1953), but the causal pathogen was not identified. Chamberlain (1961) (see Dingley 1969) reported a low incidence of a rasp leaf symptom in cherry in a few orchards in central Otago but the author suggested that it was doubtful that this was caused by the North American rasp leaf virus. In New Zealand, only cv. 'Bing' shows obvious rasp leaf symptoms, and the relationship of the causal agent to viruses causing rasp leaf in North America and Europe has not been investigated (Wood & Fry, 1972; Wood, 1979). Smith *et al*. (1988) indicated that the report from New Zealand may be out-of-date and doubtful. Pearson *et al*. (2006) reviewed the status of CRLV in New Zealand but found no supporting evidence to confirm its presence.

CRLV is therefore currently considered to be absent from New Zealand.

5.3.1.3. Biology and epidemiology

CRLV has a wide host range of herbaceous and woody plants. The virus is vectored by the dagger nematode, *Xiphinema americanum*, and is sap-transmitted to a wide range of herbaceous hosts, as well as being seed-transmitted in some weed species. *Xiphinema americanum* is considered present in New Zealand (PPIN 2009).

Morphology

CRLV has a bipartite genome and isometric particles that are ca 28-30 nm in diameter with a polyhedral in outline and contain single-stranded RNA (CPC 2007).

Symptoms on apples

In the early stages of infection, diseased trees show only a few abnormal fruits on certain branches. In later stages, the severity and percentage of affected fruit can increase substantially. Diseased trees are dwarfed, giving a dense, somewhat bushy appearance. Leaves in the affected region of the tree are small, long and narrow and appear to be coarse, brittle and dry (Blodgett *et al.*, 1963). Enations are sometimes formed (Stace-Smith & Hansen, 1976b). Fruits on affected limbs may be smaller than normal and are flattened along the longitudinal axis. Fruits show little or no indentation of the stem end and the calyx basin is open and has prominent lobes. Lateral or side branch growth is often severely reduced (CPC 2007).

Reaction severity varies considerably among cultivars. Symptoms of flat apple occur mainly on cultivars 'Delicious', 'Golden Delicious', 'Jonagold' and 'Gala'. Cultivars 'Fuji', 'Empire' and 'Granny Smith' exhibit relatively mild symptoms (Hansen & Parish 1990, WSU 2003). Because fruit symptoms similar to those of CRLV can sometimes be caused by some chemical thinning sprays, caution must be used when identifying CRLV on the basis of fruit symptoms only (Hansen & Parish, 1990).

Symptoms by affected plant part include (CPC 2007):

- Fruits/pods: abnormal shape
- Leaves: abnormal colours; abnormal forms; yellowed or dead
- Stems: canker; abnormal growth; dieback
- Whole plant: plant dead; dieback; dwarfing

Epidemiology

CRLV is transmitted by the dagger nematode *Xiphinema americanum*. Nyland *et al*. (1969) showed that *X. americanum* could transmit the virus but *X. diversicaudatum* could not. In more recent nematode transmission studies, Jones *et al*. (1995) found that CRLV was transmitted by a Pennsylvania strain of *X. americanum* (sensu stricto), as well as by *X. californicum* and *X. rivesi*. CRLV is spread very slowly by its nematode vector or by root grafting (Hansen *et al*., 1982). Unless assisted by moving water or soil, the nematode vector may only move short distances (e.g. 1 m) per year (Smith *et al*. 1997).

CRLV is readily transmitted by sap inoculation. Seed transmission at levels of 10-20% has been shown to occur in some herbaceous hosts, such as *Chenopodium quinoa* and *Taraxacum officinale*. Seeds taken from infected parts of cherry trees failed to germinate (Hansen *et al*. 1974). The virus has been detected in pollen from infected cherry trees, but transmission by pollen has not been confirmed (Jones 1987).

Local transmission by nematodes and the presence of CRLV in weeds or other native hosts probably explain the slow spread of the disease and its occurrence over much of western North America (Hansen *et al*. 1974). In Colorado, a detailed survey of a sweet cherry orchard in which CRLV was present showed a 5% increase in the disease over a 6-year period (Luepschen *et al*. 1974).

The most likely means of international dissemination of CRLV is in infected propagating material. The virus could possibly be carried by the nematode vector in soil accompanying plants, although the nematode is prone to desiccation and does not survive for long periods in dry soil. The virus has been intercepted several times in imported plant material from North America (Jones *et al*. 1985).

Host range

The principal hosts of CRLV are sweet cherry (*Prunus avium*), and peaches (*P. persica*). Susceptible cherry rootstocks include both mazzard (*P. avium*) and mahaleb (*P. mahaleb*) (Wagnon *et al*. 1968; Stace-Smith & Hansen 1976b).

There are a few published references to a rasp leaf disease symptom occurring in Montmorency sour cherry (*P. cerasus*) (Bodine *et al*. 1951; Conners & Savile 1951 & 1952). Hansen *et al*. (1982) include sour cherry in the list of hosts for CRLV. However, some reports from sour cherry are based on symptoms only and are dated. Other viruses can sometimes be associated with this type of leaf symptom in sour cherry (Nyland 1976). As a result, some reports of CRLV in sour cherry may be questionable, particularly when based on symptoms only and when reported from outside of western North America. CRLV has also been found in apple (*Malus sylvestris*), in which it causes ‘flat apple’ disease (Parish 1976 & 1977, Hansen & Parish 1990). Symptomless infection has also been reported in raspberry (*Rubus idaeus*) (Jones *et al*. 1985).

Some weed species (e.g. dandelion - *Taraxacum officinale*, plantain - *Plantago major*, and balsamroot - *Balsamorhiza sagittata*) are also reported to be symptomless hosts of CRLV

(Hansen *et al*. 1974). The presence of the virus in these weed species, which can be found growing in and around some orchards, suggests that CRLV may have originated in wild hosts such as balsamroot, and that it is spread from these reservoir hosts into orchards by nematodes.

The accepted host list for CRLV includes *Malus domestica* (apple), *Prunus avium* (sweet cherry), *Prunus cerasus* (sour cherry), *Prunus mahaleb* (mahaleb cherry), *Prunus persica* (peach), *Rubus idaeus* (raspberry), *Balsamorhiza sagittata*, *Plantago major* (broad-leaved plantain), *Taraxacum* spp. (dandelion) (CPC 2007) and *Solanum tuberosum* (potato) (Thompson *et al*. 2004).

Geographical distribution

CRLV was first found in 1935 in Colorado, USA (Bodine and Newton 1942). The virus is native to western North America where it occurs over a wide geographic area, although typically primary outbreaks are usually limited to only one or a few trees. The virus occurs primarily in the foothills west of the Rocky Mountains from Colorado, Utah and California, and north to southern British Columbia (Stace-Smith and Hansen 1976b). As other viruses can sometimes induce leaf enation symptoms similar to those of CRLV (Nyland 1976), older reports of CRLV occurring in areas outside western North America may be questionable.

CRLV is listed as being present in Canada, but few occurrences recorded (CABI/EPPO 2001; EPPO 2006). There are no reports of the virus occurring in commercial apple orchards in Canada. In the USA it is listed as having a restricted distribution (CABI/EPPO 2001; EPPO 2006). CRLV has been reported from California, Colorado, Idaho, Montana, Nebraska, New Mexico, Oregon, Utah, Washington and Wisconsin (CMI 1969; Stace-Smith & Hansen 1976b; APS-APHIS 1999). Due to the cryptic nature of many apple diseases, it is likely that CRLV is present in many other regions and countries and as such any country freedom declarations should be treated with caution.

5.3.1.4. Hazard identification conclusion

The accepted absence of CRLV in New Zealand, the ability of this virus to be vectored by *Malus* nursery stock, and its ability to cause disease symptoms on commercial plants in New Zealand all suggest that CRLV should be considered a potential hazard requiring further assessment.

5.3.2. Risk assessment

5.3.2.1. Entry assessment

In areas where CRLV has an established population, outbreaks appear limited to a few trees only. The low prevalence of this virus within infected populations suggests that the likelihood of association with trees from which any *Malus* budwood is taken for export to New Zealand is low. As with any virus, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of CRLV into New Zealand with *Malus* nursery stock is low and therefore non-negligible.

5.3.2.2. Assessment of exposure and establishment

While hosts of CRLV are available in New Zealand as they are in USA and Canada, the limited persistence of CRLV in Canadian commercial apple orchards suggests that there may be some climate constraints on the successful colonisation and spread either of the virus or its vectoring organism(s). Should this virus be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.3.2.3. Consequence assessment

Spread

It is reported that CRLV is spread very slowly by its nematode vector or by root grafting (Hansen *et al*. 1982). Unless assisted by moving water or soil, the nematode vector may only move short distances (for example, 1 m) per year (Smith *et al*. 1997). The rate of natural dispersal should therefore be considered low.

Economic consequences

CRLV can cause serious stunting of infected peach trees, and fruit yield and quality reductions in both cherries and apples. In addition, young trees and seedling rootstocks are sometimes killed. In older orchards, CRLV can reach high levels of infection and trees planted on previously infected sites can become infected. A survey in parts of Colorado, USA, showed a slow (5%) but steady increase of the disease over a six-year period. In some older cherry-producing districts of Colorado high incidences of the virus were found (23% and 38% infected trees). Affected trees showed increased winter injury mortality, although effects on actual crop yields were not determined. Within the surveyed counties, 15% of the trees examined were thought to be infected with the virus (Luepschen *et al*. 1974).

Because of its relatively slow rate of spread in most parts of western North America, the disease has usually only been of minor economic importance; occurrences have been local and limited, with only a few trees in an orchard being infected (Hansen *et al*. 1974; McElroy *et al*. 1975; Nyland 1976; Hansen & Parish 1990). As a result, in North America the virus is considered to be of little economic importance to the stone fruit industry as a whole (Hansen *et al*. 1982). CRLV is considered an A1 quarantine organism for EPPO (OEPP/EPPO 1984); is of quarantine significance for IAPSC (Smith et al., 1997) and as such would be expected to place constraints on exporters of *Malus* nursery stock from New Zealand to these regions.

CRLV is controlled by the removal of infected trees, and trees immediately adjacent to infected trees. Broadleaf weed control to eliminate alternate hosts and soil-fumigation to reduce populations of vector-nematodes are also effective in helping to control the disease (Ogawa & English, 1991). The use of certified, disease-free planting material for replants or for setting out new orchards is essential in controlling many virus diseases, including CRLV. In recent decades, the elimination of infected plants, crop rotation and the widespread use of certified planting materials by growers has ensured that CRLV, and other similar virus diseases, has remained of only minor economic importance in affected areas.

Environmental consequences

Some weed species (*i.e.* dandelion - *Taraxacum officinale*) reported to be symptomless hosts of CRLV are present in New Zealand. The presence of the virus in these weed species, which can be found growing in and around some orchards and gardens may become reservoir hosts for the virus to spread into orchards by nematodes. While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by CRLV, namely fruit and leaf distortion, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by CRLV lowering fruit yield or quality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of CRLV in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

This organism is not known to be of any significance to human health.

5.3.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that CRLV has a low likelihood of causing low to moderate unwanted economic consequences and low environmental consequences to New Zealand.

5.3.2.5. Risk estimation

The likelihood estimate is low that CRLV would be associated with *Malus* nursery stock on entry into New Zealand, high that any CRLV that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate unwanted economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for CRLV associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

5.3.2.6. Assessment of uncertainty

There is some uncertainty around the biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.3.3. Risk management

5.3.3.1. Risk evaluation

Since the risk estimate for CRLV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.3.3.2. Option evaluation

There are conceivably a number of points on the importation pathway that phytosanitary measures could be implemented to meet the aforementioned management objectives. The following risk management options should be assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of CRLV;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of CRLV;
- **c.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

In crops that show symptoms and do not show latency, such as varieties of cherry and apple, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious. Sampling and laboratory testing would then be required to confirm the identity of the causal agent as CRLV. It therefore should be considered likely that a reliable PFA determination could be obtained once an appropriate official delimiting or detection survey had been completed. A PFA declaration supported by an appropriate survey methodology could be considered an effective phytosanitary measure

Pest free place of production (PFPP)

In crops that show symptoms and do not show latency, such as varieties of cherry and apple, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious (usually late summer and autumn). Sampling and laboratory testing would then be required to confirm the identity of the causal agent as CRLV. Given the slow rate of spread of the virus through infected populations, phytosanitary measures that effectively maintain the PFPP should be relatively straightforward. It therefore should be considered likely that an effective PFPP determination could be obtained once an appropriate official delimiting or detection survey had been completed and appropriate controls are implemented.

Virus indexing of mother plants

CRLV is readily transmitted by grafting or mechanically by sap inoculation to herbaceous indicator plants (ISHS 1980). A wide range of herbaceous test plant species have been successfully inoculated in the laboratory, including *Chenopodium quinoa*, *C. amaranticolor*, *Cucumis sativus*, *Cyamopsis tetragonoloba*, *Gomphrena globosa*, *Phaseolus vulgaris*, *Sesbania macrocarpa* and *Vigna unguiculata*. Diagnostic symptoms in *C. amaranticolor* and *C. quinoa* consist of a very fine stipple or dusty mottle at the base of the leaf which persists for only a few days and is most visible in the partially expanded terminal leaves (Nyland 1976). Hansen *et al*. (1974) and Stace-Smith and Hansen (1976b) provide information on symptomology in relation to indicator plants. Inoculation of herbaceous indicators can be followed by ELISA or available PCR tests.

Sweet cherry cv. Bing is a good, woody indicator host. The virus can be detected by approach grafting from infected *C. amaranticolor*, a semi-woody indicator host, to cherry rootstock F12/1. When buds of virus-free cv. Bing sweet cherry (*Prunus avium*) are T-budded onto the recipient rootstock and allowed to grow, the leaves of the cv. Bing shoots show enations and severe deformation after 10-22 months (Li *et al*. 1996). Nyland (1976) indicated that symptom development can take anywhere from 8-9 months to as long as 2-3 years to develop in the case of graft inoculated cherry.

Oligonucleotide primers have been developed that allow reliable RT-PCR detection of CRLV in *Chenopodium quinoa*, cherry and apple (James *et al*. 2000 & 2001). The virus was reliably detected in leaf and budwood tissue of cherry and apple. Comparison of amino acid residues derived from the RT-PCR amplified 429 bp fragment associated with CRLV and the flat apple-associated isolate gave 95% identity.

It also has been reported that CRLV (flat apple isolate) can be eliminated from apple by heat therapy (James *et al*. 2001).

There is currently no information on the reliability of mechanical inoculation of CRLV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test indexing schedule should be considered an effective phytosanitary measure against CRLV (see section 4.3.1 for further discussion).

Inspection of mother plants

Generally, relying on the detection of CRLV infection without targeted testing would offer little protection on many *Malus* species or cultivars as this organism can remain latent or symptomless in some *Malus* hosts. Mother plant inspections alone should therefore be considered an effective phytosanitary measure against CRLV unless the species or cultivar being imported is not known to reliably express evidence of CRLV infection.

5.3.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

APS-APHIS (1999) Widely Present Virus List by State. APS-APHIS Virus Working Group of the Plant Virology Committee of the American Phytopathological Society for the United States Department of Agriculture's Animal and Plant Health Inspection Service, USA, at http://www.aphis.usda.gov/biotech/Stvir99.html.

Blodgett, E C; Aichele, M D; Coyier, D L; Milbrath, J A (1963) The Flat Apple Disease. Plant Disease Reporter, 47:769-771.

Bodine, E W; Blodgett, E C; Lott T B (1951) Rasp Leaf. In: Virus Diseases and other Disorders with Virus-like Symptoms of Stone Fruits in North America. United States Department of Agriculture, Agriculture Handbook 10. Washington, USA. 132-134.

Bodine, E W; Newton, J H (1942) The rasp leaf of cherry. Phytopathology, 32:333-335.

CABI/EPPO (2001) Cherry rasp leaf virus. Distribution Maps of Plant Diseases, No. 303, Edition 4. Wallingford, UK: CAB International.

Chamberlain E E (1961) Virus diseases of fruit trees. *Orchardist of New Zealand* 34 (supplement), 1–8.

CMI (1969) Distribution Maps of Plant Diseases No. 303 (edition 3). Wallingford, UK: CAB International.

Conners, IL Savile, D. BO (1951) Thirtieth Annual Report of the Canadian Plant Disease Survey, 1950; 135 pp.

Conners, IL Savile, D. BO (1952) Thirty-first Annual Report of the Canadian Plant Disease Survey, 1951; 122 pp.

CPC (2007) Crop Protection Compendium on Internet. *CAB International*, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Dingley, J M (1969) Records of plant diseases in New Zealand. Bulletin of the New Zealand Department of Scientific and Industrial Researches Bulletin, 192, 298 pp.

EPPO (2006) PQR database (version 4.5). Paris, France: European and Mediterranean Plant Protection Organization. www.eppo.org.

Fauquet C M, Mayo M A, Maniloff J, Desselberger U, Ball L A eds. (2005) Eighth Report of the International Committee on Taxonomy of Viruses. London, UK: Elsevier, pp 1259.

Hansen, A J; Nyland, G; McElroy, F D; Stace-Smith, R (1974) Origin, cause, host range and spread of cherry rasp leaf disease in North America. Phytopathology, 64(5):721-726. View Abstract

Hansen, A J; O'Reilly, H J O; Yorston, J M (1982) Stone Fruit Virus Diseases of British Columbia. Victoria, British Columbia: Ministry of Agriculture and Food.

Hansen, A J; Parish, C L (1990) Transmissible Fruit Disorders. In: Jones AL, Aldwinckle HS, eds. Compendium of Apple and Pear Diseases. St Paul, MN, USA: APS Press, 77-78.

Helson G A H (1953) Outbreaks and new records. New Zealand: FAO Plant Protection Bulletin, 1:122.

ICTVdB Management (2006) 00.111.0.01.001. Cherry rasp leaf virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA. http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.111.0.01.001.htm

ISHS (1980) Detection of viruses and other graft-transmissible virus-like diseases of fruit trees. Acta Phytopathologica Academiae Scientiarum Hungaricae, 15:407-413.

James D, Howell W E, Mink G I (2000) Development of an RT-PCR procedure for the detection of flat apple virus and molecular evidence of identity with cherry rasp leaf virus. Phytopathology (Abstr), 90(6):38

James, D; Howell, W E; Mink, G I (2001) Molecular evidence of the relationship between a virus associated with flat apple disease and Cherry rasp leaf virus as determined by RT-PCR. Plant Disease, 85(1):47-52.

Jones, A T (1987) Cherry rasp leaf virus in Rubus. In: Converse RH, ed. Virus Diseases of Small Fruits. USA: United States Department of Agriculture. Agriculture Handbook No. 631, 241-242.

Jones, A T; Mayo, M A; Henderson, S J (1985) Biological and biochemical properties of an isolate of cherry rasp leaf virus from red raspberry. Annals of Applied Biology, 106(1):101-110.

Jones, A T; Brown, D J F; Halbrendt, J M; Vrain, T C; Robbins, R T (1995) The transmission of three nepoviruses by populations of four *Xiphinema americanum*-group species. Acta Horticulturae, No. 385:105-109.

Li, T S C; Eastwell, K C; Hansen, A J (1996) Transmission of cherry viruses by approach grafting from herbaceous to woody hosts. Canadian Journal of Plant Pathology, 18(4):429-432. View Abstract

Luepschen, N S; Harder, H H; Rohrbach, K G; Sisson, M A (1974) Sweet cherry raspleaf incidence in Colorado. Plant Disease Reporter, 58(1):26-27.

McElroy, F D (1975) Nematode transmitted viruses in British Columbia, Canada. In Nematode vectors of plant viruses. pg 287-288.

Nyland, G (1976) Cherry rasp leaf. In: Virus diseases and non-infectious disorders of stone fruits in North America. USA: US Department of Agriculture. Agriculture Handbook No. 437, 219-221.

Nyland, G; Lownebery, B F; Lowe, S K; Mitchell, J F (1969) The Transmission of Cherry Rasp Leaf Virus by Xiphinema americanum. Phytopathology, 59:111-1112.

OEPP/EPPO (1984) Data sheets on quarantine organisms No. 131, *Liriomyza trifolii*. Bulletin OEPP/EPPO, 14:29-37.

Ogawa, J M; English, H eds (1991) Diseases of Temperate Zone Tree Fruit and Nut Crops. Oakland, CA, USA: University of California, Division of Natural Resources.

Parish, C L (1976) A comparison between the causal agents of cherry rasp leaf and flat apple diseases. Acta Horticulturae, 67:199-202.

Parish, C L (1977) A relationship between flat apple disease and cherry rasp leaf disease. Phytopathology, 67(8):982-984.

Pearson, M N; Clover, G R G; Guy, P L; Fletcher, J D; Beever, R E (2006) *A review of the plant virus, viroid and mollicute records for New Zealand.* Australasian Plant Pathology 35 (2): 217-252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. 3 Vol. Pl. Dis. Div. D.S.I.R; Auckland

PPIN (Year of search) Plant Information Network. MAF database.

Smith, I M; Dunez, J; Phillips, D H; Lelliott, R A; Archer, S A (1988) European Handbook of Plant Diseases. London, UK: Blackwell Scientific.

Smith, I M; McNamara, D G; Scott, P R; Holderness, M; Burger, B (1997) Quarantine Pests for Europe. Wallingford, Oxon, UK: CAB International.

Stace-Smith, R; Hansen, A J (1976a) Some properties of cherry rasp leaf virus. Acta Horticulturae, 67:193-197.

Stace-Smith, R; Hansen, A J (1976b) Cherry rasp leaf virus. Wellesbourne, UK: Association of Applied Biologists. CMI/AAB Descriptions of Plant Viruses No. 159.

Thompson J R, Perry K L, De Jong W (2004) A new potato virus in a new lineage of picorna-like viruses. *Archives of Virology* 149: pp. 2141-2154.

Wagnon, H K; Traylor, J A; Williams, H E; Weiner, A C (1968) Investigations of cherry rasp leaf disease in California. Plant Disease Reporter, 52:618-622.

Wellinck J, Le Gall O, Sanfacon H, Ikegami M, Jones A T (2000) Family Comoviridae. In van Regenmortel MHV, et al., Virus Taxonomy; Seventh Report of the International Committee on Taxonomy of Viruses, 691-701. San Diego, USA: Academic Press.

Wood, G A (1979) Virus and virus-like diseases of pome fruits and stone fruits in New Zealand. Bulletin, Department of Scientific and Industrial Research.

Wood, G A; Fry, P R (1972) Virus infection in Central Otago sweet cherry trees. New Zealand Journal of Agricultural Research, 15:172-178.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

5.4. Clover yellow mosaic virus (ClYMV)

5.4.1. Hazard identification

5.4.1.1. Aetiologic agent

Clover yellow mosaic virus (ClYMV), Genus: *Potexvirus* (Brunt *et al*. 1996, Büchen-Osmond 2003).

5.4.1.2. New Zealand status

ClYMV has not been recorded in New Zealand (Pearson *et al* 2006, PPIN 2009).

5.4.1.3. Biology and epidemiology

Microscopic disease symptoms of ClYMV include inclusions in the cytoplasm of infected cells are unusual in shape, banded and of complex structures. The inclusions contain virions and are found in mesophyll and parenchyma cells (Brunt *et al*. 1996).

Agrawal *et al*. (1962) found the virus to be mechanically transmitted with ease and thought it should be more widespread than its reported distribution at that time. While grasshoppers and other chewing insects have been implicated in the spread of potexviruses on an uncommon basis, there is no information as to which, if any, insects or other creatures are implicated in the spread of ClYMV (CSL 2005).

ClYMV has established outdoors in Canada and the USA in temperate environments on clover and other crops. Potexviruses are contagious and are spread easily by humans and tools used during cultural operations, such as pruning. Animals walking through clover or lucerne fields and farm machinery in other susceptible crops may also spread the virus. Although potexviruses are not usually transmitted by seed (Koenig 1978), ClYMV has been reported to be transmitted through 8% of seed of red clover (*Trifolium pratense*) (Hampton 1963, CSL 2005).

Hosts

Recorded natural hosts include *Chenopodium album* (fat hen), *Malus domestica* (apple), *Malus pumila*, *Malus sylvestris* (wild crab apple), *Medicago alba*, *Medicago sativa* (lucerne), *Pisum sativum* (pea), *Stellaria media* (common chickweed), *Trifolium* spp., *Vicia sativa* (common vetch) (CPC 2007, Brunt *et al*. 1996) and *Verbena canadensis* (Baker *et al*. 2004). A distinct strain of ClYMV causes a severe necrosis in field vetch (*Vicia sativa*) in Alberta, Canada. Ninety percent of vetch in a field of 16 hectares showed symptoms (Roa *et al*. 1980). ClYMV is recorded as causing a leaf pucker disease of *M. sylvestris* ‘McIntosh’ (Welsh *et al*. 1973).

Experimentally infected plants, including aubergine, broad bean, cowpea, cucumber, French bean, lettuce, lablab, Lima bean, mungbean, pea, peanut, soybean, spinach, squash, sunflower and sweet pea, mostly exhibited chlorotic or necrotic local lesions, which were systemic and mosaic. Several (3-9) families have been found to be susceptible in laboratory experiments (Brunt *et al*. 1996).

Geographic distribution

ClYMV is recorded as being present in Canada (in the south-west) and the USA (in the north-west) (Brunt *et al*. 1996). There is no record of ClYMV in Costa Rica, but, after the European Union intercepted this virus in *Verbena* cuttings from Costa Rica, it must now be considered a likely location where the virus occurs (CSL 2005).

5.4.1.4. Hazard identification conclusion

The accepted absence of ClYMV in New Zealand, the ability of this virus to be vectored by *Malus* nursery stock, and its ability to cause disease symptoms on commercially important plants in New Zealand all suggest that ClYMV should be considered a potential hazard requiring further assessment.

5.4.2. Risk assessment

5.4.2.1. Entry assessment

There is little available information on the prevalence of this virus within infected *Malus* populations. The likelihood of the association of ClYMV with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. As with any virus, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of ClYMV into New Zealand with *Malus* nursery stock is low to moderate and therefore non-negligible.

5.4.2.2. Assessment of exposure and establishment

Should ClYMV be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.4.2.3. Assessment of consequences

Spread

If transfer into the environment does occur, animals grazing in infected clover/lucerne pastures could aid dissemination within fields. Red clover (*Trifolium pratense*) seed infected with ClYMV could spread the virus to new pastures in any part of New Zealand. Natural spread without human assistance would be extremely slow (CSL 2005).

Economic consequences

The literature suggests that ClYMV is unlikely to become a serious pathogen on natural crop hosts. Early publications on the impact on clover suggested that there was the potential for a negative effect on winter survival and yield but in the absence of any later publications it does not appear to be a significant problem (CSL 2005). The spread from infected plants in glasshouses to outdoor crops or wild hosts is likely through mechanical transmission, especially if clover is growing in the glasshouse (as a contaminant) or nearby. However, the potential of the virus to cause damage to these hosts should be considered low (CSL 2005). Clover is essential to the economic competitiveness of New Zealand's pastoral industries (Dubas *et al*. 1998). An assessment of the agronomic impact of a related clover viral disease, white clover mosaic virus (also a potexvirus) (WClMV), considered that the economic impacts of this virus were substantial (Dubas *et al*. 1998).

The potential economic impact of ClYMV on the New Zealand agricultural sector in combination with WClMV and other clover diseases should therefore be considered low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by ClYMV, namely localised leaf necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by ClYMV lowering fruit yield or quality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of ClYMV in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

This organism is not known to be of any significance to human health.

5.4.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that ClYMV has a low likelihood of causing moderate to high unwanted-economic consequences and low environmental consequences to New Zealand.

5.4.2.5. Risk estimation

The likelihood estimate is low that ClYMV would be associated with *Malus* nursery stock on entry into New Zealand, high that any ClYMV that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate unwanted-economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for ClYMV associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

5.4.2.6. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.4.3. Risk management

5.4.3.1. Risk evaluation

Since the risk estimate for ClYMV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.4.3.2. Option evaluation

There are conceivably a number of management options available for ClYMV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ClYMV;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ClYMV;
- **c.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.

d. Inspection of mother plants.

Pest free area (PFA)

In crops that show symptoms, such as clover, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious (e.g. early spring). Sampling and laboratory testing would then be required to confirm the identity of the causal agent as ClYMV. It therefore should be considered likely that a reliable PFA determination could be obtained once an appropriate official delimiting or detection survey had been completed. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

In crops that show symptoms, such as clover, the virus could be detected by visual inspection of the growing crop for typical symptoms. Inspections would need to occur at the appropriate times of the year when symptoms would be most obvious (e.g. early spring). Sampling and laboratory testing would then be required to confirm the identity of the causal agent as ClYMV. Given the slow rate of normal (unassisted) spread of the virus through infected populations, phytosanitary measures that effectively maintain the PFPP should be relatively straightforward. It therefore should be considered likely that a reliable PFPP determination could be obtained once an appropriate official delimiting or detection survey had been completed and appropriate controls implemented. Under these circumstances a PFPP declaration could be considered an effective phytosanitary measure.

Virus indexing of mother plants

ClYMV is readily transmitted by grafting or mechanically by sap inoculation to herbaceous indicator plants (Brunt *et al*. 1996). Potential herbaceous indicator plants and diagnostic symptoms include *Chenopodium quinoa* and *Gomphrena globosa* (systemic mosaic symptoms); *Medicago sativa* (local lesions, some strains only); *Pisum sativum* (necrotic local lesions, systemic mosaic symptoms); and *Vigna unguiculata* (local infection only) (Büchen-Osmond 2003). Inoculation of herbaceous indicators can be followed by ELISA testing of symptomatic material (CSL 2005).

There is currently no information on the reliability of mechanical inoculation of ClYMV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test schedule described here should be considered an effective phytosanitary measure against ClYMV (see section 4.3.1 for more discussion).

Inspection of mother plants

Relying on the detection of ClYMV infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against ClYMV.

5.4.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Agrawal, H, Bos, L, Chessin, M (1962) Distribution of clover yellow mosaic and white clover mosaic viruses on white clover in the United States. *Phytopathology* 52, 517-519.

Baker, C A, Beckham, K, Hiebert, E (2004) A virus related to *Clover yellow mosaic virus* found east of the Mississippi River in *Verbena canadensis* in Florida. *Plant Disease* 88, 223.

Brunt, A A, Crabtree, K, Dallwitz, M J, Gibbs, A J, Watson, L and Zurcher, E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*; Available at: http://image.fs.uidaho.edu/vide/

Büchen-Osmond, C. (Ed) (2003) 00.056.0.01.005. Clover yellow mosaic virus. In: *ICTVdB - The Universal Virus Database*, version 3. Büchen-Osmond, C. (Ed), ICTVdB Management, Columbia University, New York, USA; Available at: http://phene.cpmc.columbia.edu/EntVir/Data/www/56001005.htm

CPC (2007) *Crop Protection Compendium on Internet.* CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

CSL (2005) Pest Risk Analysis for Clover yellow mosaic virus. *Central Science Laboratory*, Sand Hutton, York, pp 8

Dudas, B; Woodfield, D R; Tong, P M; Nicholls, M F; Cousins, G R; Burgess, R; White, D W R; Beck, D L; Lough, T J, Forster, R L S (1998) Estimating the agronomic impact of white clover mosaic virus on white clover performance in the North Island of New Zealand. 41(2): 171-178.

Hampton, R O (1963) Seed transmission of white clover mosaic and clover yellow mosaic virus in red clover. *Phytopathology* 53, 1139.

Koenig, R (1978) Potexvirus Group. *CMI/AAB Descriptions of Plant Viruses*, No. 200, CAB/AAB.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

Roa, D V, Hiruki, C, Matsumato, T (1980) The identification and characterization of a vetch strain of clover yellow mosaic virus. *Phytopathologische Zeitschrift* 98, 260-267.

Welsh, M F, Stace-Smith, R, Brennan, E (1973) Clover yellow mosaic virus from apple trees with leaf pucker disease. *Phytopathology* 63, 50-57.

5.5. Horseradish latent virus (HRLV)

5.5.1. Hazard identification

5.5.1.1. Aetiologic agent

Horseradish latent virus (HRLV), Family: *Caulimoviridae*; Genus: *Caulimovirus* (Fauquet 2005, ICTVdB Management 2006).

5.5.1.2. New Zealand status

The virus has not been reported in New Zealand (Pearson *et al* 2006, PPIN 2009)

5.5.1.3. Biology and epidemiology

Very little information is available on this virus.

Horseradish latent virus (HRLV) was first reported in *Armoracia rusticana* (horseradish) from the USA, but in plants imported into the USA from Denmark (Brunt *et al*. 1996). The virus is reportedly transmitted within Denmark by an aphid vector, *Myzus persicae* (Hemiptera, Aphididae), and by mechanical inoculation (Richins & Shepherd 1986, Brunt *et al*. 1996).

Experimental hosts of HRLV recorded in ICTVdB Management (2006) include *Armoracia rusticana*, *Brassica campestris*, *Brassica campestris* ssp. *napus*, *Brassica campestris* ssp. *pekinensis*, *Brassica campestris* subsp. *rapa*, *Malus sylvestris*, and *Matthiola incana*. Susceptibility to experimental virus infection may not equate to a susceptibility under natural conditions.

No conspicuous symptoms were recorded in American cultivars of *Armoracia rusticana* (Brunt *et al*. 1996).

5.5.1.4. Hazard identification conclusion

As the association of HRLV with *Malus* seems only to be recorded as experimental, there is no evidence that under natural conditions this virus will be introduction into New Zealand on imported *Malus* material. Therefore for *Malus* nursery stock imported into New Zealand HRLV is not considered at this time to be a hazard.

5.5.1.5. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this virus, including whether it is naturally associated with *Malus* cultivars. As such this risk assessment should be reviewed once further relevant information becomes available.

5.5.2. References

Brunt, A A, Crabtree, K, Dallwitz, M J, Gibbs, A J, Watson, L and Zurcher, E J (eds.) (1996 onwards). Plant Viruses Online: Descriptions and Lists from the VIDE Database. Available at: http://image.fs.uidaho.edu/vide/

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses. Elsevier Academic Press, London, UK; 1259 pp.

ICTVdB Management (2006) 00.015.0.01.007. Horseradish latent virus. In: ICTVdB - The Universal Virus Database, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.015.0.01.007.htm

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

Richins, R D; Shepherd, R J (1986) Horseradish Latent Virus, a new member of the Caulimovirus group. Phytopathology 76, pp 749-754

5.6. Sowbane mosaic virus (SoMV)

5.6.1. Hazard identification

5.6.1.1. Aetiologic agent

Sowbane mosaic virus (SoMV), Genus: *Sobemovirus* (Brunt *et al*. 1996, ICTVdB Management 2006)

5.6.1.2. New Zealand status

The virus has not been reported in New Zealand (Pearson *et al.* 2006, PPIN 2009)

5.6.1.3. Biology and epidemiology

SoMV was first reported in *Chenopodium murale* from Riverside, California, USA (Brunt *et al*. 1996). The virus is probably transmitted by an insect vector e.g. *Myzus persicae*, *Circulifer tenellus*, *Liriomyza langei*, *Halticus citri*. It is considered unlikely that any of Aphididae, Cicadellidae, Coleoptera or Diptera transmit SoMV frequently or specifically. SoMV is transmitted by mechanical inoculation, grafting, seed (up to 60% in *Chenopodium quinoa* and 20-70% in *Chenopodium murale*), pollen to the seed, and pollen to the pollinated plant (Brunt *et al*. 1996).

Brunt *et al*. 1996 lists *Chenopodium* spp., *Vitis* sp., *Prunus domestica*, and *Atriplex suberecta* as natural hosts and up to 20 other susceptible hosts including one in the Rosaceae. Symptoms in these hosts include systemic chlorotic mottling (*Chenopodium* spp.) and stunting and leaf deformation (*Atriplex suberecta*). Although *Malus* and *Prunus* species are reported as becoming latently infected as a likely host, no symptoms are evident (WSU 2003).

SoMV is well documented as a problem contaminant in *Chenopodium* indicators. The 'apple latent virus 2' detected with *C. amaranticolor* was soon re-identified as SoMV, possibly introduced via the test plants used (Bancroft & Tolin 1967). Bos & Huijberts (1996) noted that SoMV "*has been of main concern to plant virologists as a contaminant, particularly from Chenopodium test or indicator plants (Engelbrecht & Van Regenmortel 1968). Infection from seed may be semi-latent or symptomless, especially during summer, and symptoms in plants infected from the seed may be provoked by rub-inoculation with water (Engelbrecht & Van Regenmortel 1968). Hence, reported natural occurrence of the virus when Chenopodium spp. are used as indicator is questionable*".

SoMV is reported to spread in the South and Central American region, Australia, Bulgaria, Canada, the former Czechoslovakia, Italy, Japan, the USA, and the former Yugoslavia (Brunt *et al*. 1996).

5.6.1.4. Hazard identification conclusion

It seems likely that the recorded occurrence of SoMV in *Malus* cultivars was a result of contaminated indicator plants, in this case *Chenopodium* indicators, rather than a true record of a host association. Therefore SoMV should not be considered a potential hazard on imported *Malus* nursery stock and as such does not require further assessment.

5.6.1.5. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this virus, especially in relation to the host status of *Malus*. As such this risk assessment should be reviewed once further relevant information becomes available.

5.6.2. References

Bancroft JB, Tolin SA (1967) The Problem of Sowbane Mosaic Virus Contamination Apple latent virus 2 is sowbane mosaic virus. *Phytopathology* 57, 639-640

Bos L, Huijberts N (1996) Occurrence and transmission of sowbane mosaic virus in seed from naturally infected plants of spinach (*Spinacia oleracea*). *European Journal of Plant Pathology* 102, pp 707-711

Brunt, A A, Crabtree, K, Dallwitz, M J, Gibbs, A J, Watson, L and Zurcher, E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*. Available at: http://image.fs.uidaho.edu/vide/

CPC (2005) Crop Protection Compendium on Internet. *CAB International*, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Engelbrecht DJ, Regenmortel MHV (1968) The Problem of Sowbane Mosaic Virus Contamination. *Journal of Phytopathology* 63 (1), pp 10-14

ICTVdB Management (2006) 00.067.0.01.008. Sowbane mosaic virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA; at http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.067.0.01.008.htm

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) *"Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

5.7. Tomato bushy stunt virus (TBSV)

5.7.1. Hazard identification

5.7.1.1. Aetiologic agent

Tomato bushy stunt virus (TBSV), Family: *Tombusviridae*, Genus: *Tombusvirus* (CPC 2007, ICTVdB Management 2006).

5.7.1.2. New Zealand status

The virus has not been reported in New Zealand (Pearson *et al.* 2006, PPIN 2009)

5.7.1.3. Biology and epidemiology

TBSV virons are found in all parts of the host plant: in cytoplasm, in nuclei, in nucleoli, in mitochondria, and in cell vacuoles. TBSV was first reported in *Lycopersicon esculentum* from England and is mainly considered to infect *Capsicum annuum* (bell pepper), *Lycopersicon esculentum* (tomato), *Solanum melongena* (aubergine) (CPC 2007). TBSV can reach a relatively high incidence on apple (28%), but is rare on other fruit trees (Kegler *et al*. 1980). Apples and pears infected by a poorly characterized TBSV strain from Eastern Germany were symptomless (Kegler *et al.* 1983, Brunt *et al*. 1996). WSU 2003 considers this virus to be of no risk on pome fruit in the USA.

TBSV induces ‘cherry destructive canker disease’ symptoms in cherry trees. Symptoms first appear in spring and may continue in later growth. Leaf blades are sharply twisted sideward and downward because of necrosis of the midrib and main veins. Shoots are short and from a distance the tree may appear rosetted. Necrosis of the shoots also results in a peculiar zigzag growth. Bark canker with strong gum flow also has been observed. Most cultivars have poor fruit set. The fruits are malformed by sunken, circular pits beneath which the flesh is necrotic (CPC 2007).

Natural host range and symptoms include (CPC 2007, ICTVdB Management 2006):

- *Lycopersicon esculentum* - bushy growth, fewer smaller fruits with chlorotic blotching, rings and line pattern.
- *Capsicum annuum* - stunting, mottling, deformation of the leaves, no fruit.
- *Solanum melongena* - stunting, leaf mottling and crinkling; few spotted and deformed fruit.
- *Tulipa* spp. - leaf and petal necrosis.
- *Tolmiea menziesii* - stunting and leaf mottling.
- *Malus* spp., *Pyrus* spp. - no symptoms.

Kegler *et al*. 1980 reported that TBSV was also recorded on *Stellaria media*, *Poa annua* and *Urtica urens*.

A vector has yet to be identified for the transmission of TBSV. The virus is considered to be transmitted by mechanical inoculation, grafting, seed (at a low rate e.g. 5.8% in apple), and possibly transmitted by pollen to the seed (e.g. *Prunus avium*), but is not transmitted by contact between plants (CPC 2007, Kegler *et al*. 1980). TBSV is released by roots of infected plants into the soil and may attack other plant roots without the need of an insect vector. The virus occurs in the free state in natural soil, where it remains infective for 12 weeks (Kegler *et al*. 1980)

TBSV spreads (principally on plants in the Solanaceae) in Argentina, Morocco, Tunisia, the UK, and the USA (in California). It is also found, but with no evidence of spread, in Portugal, France, Italy, Germany and Canada (CPC 2007, ICTVdB Management 2006).

5.7.1.4. Hazard identification conclusion

The accepted absence of TBSV in New Zealand, the ability of this virus to be vectored by *Malus* nursery stock, and its ability to cause disease symptoms on commercial plants in New Zealand all suggest that TBSV should be considered a potential hazard requiring further assessment.

5.7.2. Risk assessment

5.7.2.1. Entry assessment

In areas where TBSV has an established population, incidence on apple has been recorded as reaching a relatively high level (28%). This suggests that in a contaminated region the likelihood of association with trees from which any *Malus* budwood is taken for export to New Zealand is moderate to high. As with any virus, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of TBSV into New Zealand with *Malus* nursery stock from an infected area is moderate to high and therefore non-negligible.

5.7.2.2. Assessment of exposure and establishment

Should this virus be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.7.2.3. Consequence assessment

Spread

As TBSV is:

- unlikely to be transmitted by insect vectors or contact between plants;
- is known to be transmitted by mechanical inoculation, grafting, seed, and pollen to the seed; and
- has hosts or potential hosts that are widespread in the New Zealand environment;

TBSV should be expected to spread through the New Zealand environment rapidly especially if assisted by human intervention.

Economic and environmental consequences

While latent infection of *Malus* can occur, no symptoms and subsequently no impacts have been observed. Impacts in other symptomatic hosts would be expected to be more significant. The host range of TBSV includes some important horticultural and amenity species such as *Capsicum annuum* (bell pepper), *Lycopersicon esculentum* (tomato), and *Solanum melongena* (aubergine).

Infection levels of 40-50% were recorded in tomato fields from Tunisia and Spain, whilst in California, USA, and the yield of affected tomato crops was reduced by as much as 80% (CPC 2007). Equivalent effects on tomato plants in New Zealand would cause impacts on domestic production affecting both commercial or economic outcomes and social outcomes. As such TBSV is considered to have a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

Consequences to human health

There are no recorded instances of plant viruses causing diseases in humans and therefore is not expected to be of any significance to human health.

5.7.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that TBSV has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

5.7.2.5. Risk estimation

The likelihood estimate is moderate to high that TBSV would be associated with *Malus* nursery stock on entry into New Zealand from an infested area; high that any TBSV that does enter would successfully establish in New Zealand; and low that the establishment would result in low to moderate unwanted economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for TBSV associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

5.7.2.6. Assessment of uncertainty

There is uncertainty around the biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.7.3. Risk management

5.7.3.1. Risk evaluation

Since the risk estimate for TBSV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.7.3.2. Option evaluation

There are conceivably a number of management options available for TBSV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of TBSV;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of TBSV;
- **c.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

Given the paucity of information available on the epidemiology of TBSV and the symptomless nature of infection in *Malus*, it may not be possible to develop adequate criteria for establishing and maintaining a PFA. Detection and screening systems based on the use of ELISA and PCR tests could be used. A PFA declaration for TBSV could be considered an effective phytosanitary measure should appropriate criteria be developed.

Pest free place of production (PFPP)

Given the paucity of information available on the epidemiology of TBSV and the symptomless nature of infection in *Malus*, it may not be possible to develop adequate criteria for establishing and maintaining a PFPP. Detection and screening systems based on the use of ELISA and PCR tests could be used. A PFPP declaration for TBSV could be considered an effective phytosanitary measure should appropriate criteria be developed.

Virus indexing of mother plants

Mechanical inoculation tests from the mother plants onto susceptible host material such as those listed below should ensure disease symptoms become apparent. Mechanically inoculated plants of *Gomphrena globosa* produce characteristic local lesions within 24-36 hours and those of *Ocimum basilicum* in less than a week (Brunt *et al*. 1996). Indicative symptoms on these hosts are also listed below. Inoculation of herbaceous indicators can be followed by ELISA or PCR testing of symptomatic material.

Diagnostically susceptible host species and symptoms (Brunt *et al*. 1996, ICTVdB Management 2006):

- *Gomphrena globosa* - necrotic reddish local lesions, some isolates infect systemically.
- *Ocimum basilicum* - necrotic black local lesions with lighter centre, not systemic.
- *Chenopodium amaranticolor* - whitish necrotic dots with chlorotic haloes, rarely systemic.
- *Chenopodium quinoa* - chlorotic local lesions, rarely systemic.
- *Nicotiana clevelandii* - chlorotic or necrotic local lesions, systemic mottle and necrosis.
- *Nicotiana glutinosa* - brown necrotic local lesions.

There is currently no information on the reliability of mechanical inoculation of TBSV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test schedule described here should be considered an effective phytosanitary measure against TBSV (see section 4.3.1 for further discussion).

Inspection of mother plants

Relying on the detection of TBSV infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against TBSV.

5.7.4. References

CPC (2007) Crop Protection Compendium on Internet. CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Kegler, H; Kegler, G; Kleinhempel, H (1983) Epidemiological investigations on carnation ringspot virus and tomato bushy stunt virus in fruit orchards. Zeszyty Problemowe Postepow Nauk Rolniczych 291: 155-162.

Brunt, A A, Crabtree, K, Dallwitz, M J, Gibbs, A J, Watson, L and Zurcher, E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*. Available at: http://image.fs.uidaho.edu/vide/

ICTVdB Management (2006) 00.074.0.01.001. Tomato bushy stunt virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA; at http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.074.0.01.001.htm

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures); at http://nrsp5.prosser.wsu.edu/index.html.

5.8. Tomato ringspot virus (ToRSV)

5.8.1. Hazard identification

5.8.1.1. Aetiologic agent

Tomato ringspot virus (ToRSV), Family: *Comoviridae*, Genus: *Nepovirus* (ICTVdB Management 2006).

Fauquet *et al.* (2005) listed five strains of ToRSV, namely: Grape yellow vein virus (GraYVV), Nicotiana virus13 (NV13), Peach yellow bud mosaic virus (PYBMV), Tobacco ringspot virus 2 (TbRSV-2), and Tomato ringspot virus (ToRSV). Aside from Nicotiana virus13 (NV13) these supposed strains are listed in ICTVdB Management (2006) as synonyms of ToRSV along with Blackberry Himalaya mosaic virus, Euonymus ringspot virus, Prune brown line virus, Prunus stem-pitting virus, Red currant mosaic virus and Winter peach mosaic virus.

ICTVdB Management (2006) lists 4 strains or isolates:

- Tobacco strain
- Grape yellow vein strain
- Apple union necrosis virus
- Euonymus chlorotic ringspot virus

There is no information available on the host specificity of these different strains or isolates. Further Forer *et al.* (1984) notes that, from observations of peach plants infected by other strains of ToRSV, "*perhaps factors other than the strain of ToRSV are important in symptom development*".

5.8.1.2. New Zealand status

Pearson *et al* (2006) reviewed the status of the viruses recorded in New Zealand and reported that ToRSV was recorded in New Zealand on:

- *Cymbidium sp.*, originally recorded by Young and Blundell in 1979;
- *Ribes rubrum* (red current), originally recorded by Fry and Wood in 1978; and
- *Vitis vinifera* (grapevine), originally recorded by Matthews and Milne in 1986.

Given that ToRSV has yet to be reported on *Malus* or other common hosts in New Zealand, it is likely that one or more strains of ToRSV will not be present in New Zealand.

5.8.1.3. Biology and epidemiology

Symptoms of ToRSV differ widely on different hosts. Oakleaf, ringspot or yellow blotch patterns on the foliage of perennial hosts are commonly observed in the year following infection but, in subsequent years, a general decline in plant growth and a reduction in fruit set are more common than any distinctive foliar symptoms (CPC 2007).

Symptoms related to *Malus*:

Apple union necrosis and decline caused by ToRSV is strongly associated with the *Malus domestica* (apple) cultivars propagated on MM106 clonal rootstocks of trees with union incompatibility symptoms. Although the evidence is not conclusive in all cases, the association between ToRSV infection and the occurrence of the disease is sufficiently strong to implicate the virus as a major cause of the disease. The most reliable diagnostic symptoms are pitting, invagination and necrosis in the woody cylinder at the graft union, which is thought to result from differences in rootstock and scion susceptibility since the virus is often detected in rootstocks but not in scions of diseased trees (CPC 2007). ToRSV is concentrated in the roots of the tree (CFIA-ACIA 2005a).

At bearing age, infected trees exhibit symptoms similar to those following trunk girdling: small, greenish yellow leaves, short internodes, ample flowering, and many small, bright fruits. Bark turns reddish with protruding lenticels, lateral leaves and buds die off, and terminal shoots are short and clustered. The trunk above the graft may swell, a transverse split may form and the stem can then be readily broken off. Removal of the abnormally thick and spongy bark at the scion/stock union reveals a distinct necrotic line. The disintegration of the graft union and the presence/quantity of necrotic tissue embedded into the wood depend on the scion/rootstock combination. More suckers than normal develop from below the graft union (CPC 2007, Stouffer & Uyemoto 1976).

Other recorded hosts include *Cymbidium* sp., *Fragaria chiloensis* (Chilean strawberry), *Nicotiana tabacum* (tobacco), *Pelargonium* (pelargoniums), *Prunus* (stone fruit), *Prunus armeniaca* (apricot), *Prunus avium* (sweet cherry), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Prunus persica* (peach), *Ribes* (currants), *Rubus* (blackberry, raspberry), *Rubus idaeus* (raspberry), *Vitis, Vitis vinifera* (grapevine), *Capsicum* (peppers), *Cornus* (Dogwood), *Gladiolus hybrids* (sword lily), *Hydrangea* (hydrangeas), *Lotus corniculatus* (bird's-foot trefoil), *Lycopersicon esculentum* (tomato), Orchidaceae (orchids), *Rubus procerus, Sambucus* (Elderberry), *Vaccinium corymbosum* (blueberry), *Taraxacum officinale* complex (dandelion) (CPC 2007)

Epidemiology

It is believed that ToRSV can be transmitted by nematodes (*Xiphinema*, Dorylamidae, *Xiphinema americanum sensu lato*), mechanical inoculation, grafting, seed, pollen to the seed, and pollen to the pollinated plant (Brunt *et al*. 1996). *Xiphinema americanum* is recorded as being present in New Zealand (PPIN 2009).

With the exception of strawberry, CPC 2007 reports that there is no conclusive evidence for transmission of ToRSV from seed to seedlings in any host. Seeds harvested from inoculated soybean plants grown in a greenhouse were planted in the greenhouse and the pathogen was recorded in 76% of seedlings. The presence of the virus on 3-week-old seedlings was confirmed by symptom development and by inoculating tissues onto cowpea indicator plants. However, there was no indication that precautions were taken in this study to preclude alternate sources of inoculum. Furthermore, seed transmission has not been demonstrated by seeds from naturally infected soybean plants (CPC 2007).

ToRSV can infect apples in a number of ways. Infection can occur through the propagation of trees from infected rootstocks or through nematode transmission in the nursery or in the orchard after the trees have been established. The virus can be introduced into an orchard in plantings of infected trees or seeds of infected weeds such as dandelion. Once established, it is spread through the orchard by dagger nematodes and by seeds of infected weeds. Furthermore, it can persist in the soil, in roots of infected perennial plants, and in common weeds. Thus, it is very difficult to eradicate the virus once it has become established in an orchard, although dandelion, the major distribution agent, is easily controlled with herbicides (Jones & Aldwinckle 1990).

There appears to be little, if any, spread of ToRSV by infected scions, possibly because most commercial scions are resistant to infection or because the virus does not move systematically in the scion much above the graft union. On the other hand, ToRSV is easily spread by infected

MM.106 rootstock, because it moves systemically throughout the plant without causing any obvious deleterious effects (Jones & Aldwinckle 1990, Stouffer & Uyemoto 1976).

Distribution

ToRSV has been recorded as being present in Asia (China, Iran, Japan, Republic of Korea, Oman, Pakistan, Turkey), Europe (Belarus, Croatia, Denmark, Finland, France, Germany, Italy, Lithuania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, United Kingdom), Africa (Egypt, Togo, Tunisia), North America (Canada, Mexico, USA), Central America (Puerto Rico), South America (Argentina, Chile, Peru, Venezuela), and Oceania (Australia, New Zealand) (CPC 2007)

5.8.1.4. Hazard identification conclusion

The potential that strains of ToRSV affecting *Malus* may not be established in New Zealand and the ability of this virus to be vectored by *Malus* nursery stock and cause disease symptoms on commercial plants in New Zealand all suggest that ToRSV should be considered a potential hazard requiring further assessment.

5.8.2. Risk assessment

5.8.2.1. Entry assessment

ToRSV has a wide geographic distribution and is capable of infecting both wild and cultivated plants. However, contaminated scion material is not considered an important source of infection. Because the virus is common in dandelions in apple orchards and survives in a proportion of seed from infected plants, infected dandelion seed is thought to be a major source for both inter-orchard and intra-orchard spread. The vector nematodes, which are prevalent in many orchards, may acquire the virus from orchard weed hosts and transfer it to apple trees. The vector nematodes are not expected to be associated with clean budwood.

It is therefore considered that the likelihood of entry of ToRSV into New Zealand with *Malus* nursery stock is low for susceptible cultivars and therefore non-negligible for those cultivars. The likelihood of entry of ToRSV on cultivars of *Malus* considered resistant to ToRSV infection is considered negligible.

5.8.2.2. Assessment of exposure and establishment

Should ToRSV be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.8.2.3. Consequence assessment

Spread

Many hosts affected by this virus are readily available in the PRA area. Apart from *Grape yellow vein virus* it is not clear whether other strains are present in New Zealand. New Zealand's climate should be considered highly suitability for the spread of the virus (and its strains).

The virus spreads by a soil-borne vector, nematodes from the *Xiphinema* genus. The occurrence of devastating diseases associated with the virus is correlated with the occurrence of high populations of these nematode vectors. At lease six nematodes in the *Xiphinema* genus have been recorded in New Zealand - *X. diversicandatum* (Micoletzky 1927) Thorne 1939, *X.*

radicicola Goodey 1936, *X. Krugi* Lordello 1955, and three species in the *Xiphinema americanum* (Cobb 1913) group ("a", "b" and "c") are considered to be present in New Zealand (Sturhan *et al* 1997). Knight *et al*. (1997) reviewed records of plant-parasitic nematodes in association with hosts in New Zealand and reported that *X. diversicandatum* was the most common one associated with a wide range of hosts.

Furthermore, it would be difficult to control the spread of the virus once it becomes established. ToRSV infections are usually not detected in field plantings of perennial crops until the virus has spread to produce circular patches of unthrifty plants. At this stage little can be done to prevent the progress of the virus and its control is difficult. Plants showing symptoms can be removed and replanted with healthy stock but, unless measures are taken to destroy viruliferous nematodes, the virus will soon spread into the healthy plants in the replanted area.

ToRSV can also be transmitted by grafting, by pollen to the seed, or by pollen to the pollinated plant, by seed (*Fragaria* × *ananassa*) and by mechanical inoculation.

It is therefore recommended that the likelihood of spread be considered high.

Economic consequence

ToRSV is widespread in perennial plant species and causes severe decline in productivity so it is one of the most damaging plant viruses in North America. The virus is prevalent in dandelion and other weeds and may be disseminated over considerable distances in windblown seeds of infected dandelion. Furthermore, dandelion and other perennial weeds provide reservoirs for virus acquisition by nematode vectors (CPC 2007).

ToRSV constitutes a serious economic problem in areas where the nematode vectors occur. Fortunately, pockets of active virus spread are restricted to certain soil types. In the raspberry-growing region of the Pacific Northwest, for instance, relatively few fields are infected, but where the virus is prevalent, crop losses are extensive (CPC 2007).

Yield reduction in the various perennial hosts is difficult to assess because the response to infection varies according to cultivar and the duration of infection. In studies on raspberries, between 10% and 80% of raspberry canes were partially or completely killed 3 years after becoming infected. In other field studies, observed that fruit from infected canes weighed 21% less than normal fruit and that the yield of diseased plants was reduced by >50% (CPC 2007).

Varying effects recorded in different hosts include:

- grapevine cv. DeChaunac, yield reduced by up to 95% in the Niagara peninsula of Canada (Dias 1977);
- peach stunting (CPC 2007);
- white ash had 10–50% branch dieback and decline (Hibben 1983);
- severe mosaic and decline of grapevines and of peaches, nectarines and apples (CPC 2007); and
- raspberry canes stunting (Freeman 1975, Converse 1971).

In tomatoes in Pakistan infected with a range of viruses including ToRSV, there was a significant decrease in fruit yield, fruit weight was reduced by up to 22%, fruit number by between 15 and 79% and plant height by up to 26% (CPC 2007).

Should any of the strains potentially not already in New Zealand be introduced, the economic impact could potentially be moderate considering the significant damage it can cause to the wide range of host crops overseas that to date have not been apparent in New Zealand. The impact on exports could also by high taking into account the loss on quality and yield, as well as the extra phytosanitary requirements that may be imposed by other countries (e.g. EPPO quarantine pest A2 list).

Environmental consequences

Some weed species (i.e. dandelion - *Taraxacum officinale*) reported to be hosts of ToRSV are present in New Zealand. The presence of the virus in these weed species, which can be found growing in and around some orchards and gardens may become reservoir hosts for the virus to spread into orchards by nematodes. It is also likely that, given the large host range of ToRSV, a number of native plants will act as hosts of ToRSV and suffer reductions in vigour. It is therefore recommended that there should be considered a low likelihood that potential environmental consequences could be low to moderate.

Human health consequences

This organism is not known to be of any significance to human health.

5.8.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that ToRSV has a moderate likelihood of causing moderate to high economic consequences and a low likelihood of causing low to moderate environmental consequences to New Zealand.

5.8.2.5. Risk estimation

The likelihood estimate is low that ToRSV would be associated with *Malus* nursery stock on entry into New Zealand, high that any ToRSV that does enter would successfully establish in New Zealand, moderate that the establishment would result in moderate economic consequences, and low that the establishment would result in low to moderate environmental consequences to New Zealand. As a result the risk estimate for ToRSV associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

5.8.2.6. Assessment of uncertainty

There is some uncertainty around the biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.8.3. Risk management

5.8.3.1. Risk evaluation

Since the risk estimate for ToRSV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.8.3.2. Option evaluation

There are conceivably a number of management options available for ToRSV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ToRSV;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ToRSV;
- **c.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.

d. Inspection of mother plants.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Problems encountered in the detection and identification of ToRSV in raspberry may be used as an example, since similar problems are encountered in detecting the virus in other perennial hosts. Infections in raspberry may be detected by field examination, particularly if surveys are conducted in the spring when foliage symptoms are most pronounced. Field surveys detect a high proportion of new infections but a low proportion of chronically infected plants. Some sensitive cultivars show foliar markings on at least a few canes in most years; other cultivars show no symptoms (CPC 2007).

Since the absence of symptoms does not necessarily mean absence of infection, visual examinations must be supplemented with tests capable of detecting latent infections. Visual inspections are usually supplemented with sap transmissions to indicator plants or serological tests (CPC 2007). Given the absence of a reliable low cost method for detecting and identifying the presence of ToRSV, a reliable PFA determination may not be able to be obtained. While ELISA is now widely used for field surveys (CPC 2007) this test may not be sensitive enough for adequate PFA declarations. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As detailed for PFA above, given the absence of a reliable low cost method for detecting and identifying the presence of ToRSV, a reliable PFPP determination may not be able to be obtained. While ELISA is now widely used for field surveys (CPC 2007) this test may not be sensitive enough for adequate PFPP declarations. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Virus indexing of mother plants

Two tests for the diagnosis of ToRSV are useful: sap transmissions from perennial hosts to herbaceous hosts or direct serological tests on sap extracted from the perennial host tissue (CPC 2007). Sap transmissions from infected perennial hosts to herbaceous host species are readily achieved providing succulent leaf tissue is used as the source of inoculum. The most useful indicator hosts are *Chenopodium quinoa* and *Cucumis sativus* (CPC 2007). While symptom expression is readily achieved on these hosts, other nepoviruses cause similar symptoms. Serological or PCR tests are therefore required for a positive identification (CPC 2007).

The following diagnostic host species and symptoms are listed in the 'Universal Virus Database' (ICTVdB Management 2006):

Chenopodium amaranticolor and *C. quinoa* - chlorotic local lesions, systemic apical necrosis.

Cucumis sativus - necrotic or chlorotic local lesions; systemic mottle.

Phaseolus vulgaris - chlorotic local lesions; systemic rugosity, tip necrosis.

Vigna unguiculata - necrotic or chlorotic local lesions; systemic tip necrosis.

Lycopersicon esculentum - necrotic flecking; systemic mottle, necrosis.

Nicotiana clevelandii - necrotic local lesions; systemic chlorosis, necrosis.

N. tabacum - necrotic local lesions or ringspot markings; systemic ring or line patterns.

Petunia x hybrida - necrotic local lesions; tip necrosis.

Bioassays are effectively used with foliage produced in the spring, but as summer progresses, it becomes difficult to detect infection (CPC 2007). Enzyme-linked immunosorbent assay (ELISA) is the most reliable and can be used to detect the virus in leaf, stem, bud, and root samples from infected plants. ELISA is now widely used for field surveys (CPC 2007).

There is currently no information on the reliability of mechanical inoculation of ToRSV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test schedule described here should be considered an effective phytosanitary measure against ToRSV (see section 4.3.1 for more discussion).

Inspection of mother plants

Relying on the detection of ToRSV infection using visual inspection only without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against ToRSV.

5.8.4. References

Brunt, A A, Crabtree, K, Dallwitz, M J, Gibbs, A J, Watson, L and Zurcher, E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*. Available at: http://image.fs.uidaho.edu/vide/

CFIA-ACIA (2005a) Virus testing of *Malus* spp. by woody host bioassay. Centre for Plant Health, Canadian Food Inspection Agency; pp 17.

Converse RH, Stace-Smith R, 1971. Rate of spread and effect of tomato ringspot virus on red raspberry in the field. Phytopathology, 61:1104-1106.

CPC. Crop Protection Compendium on Internet. CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Dias HF, 1977. Incidence and geographic distribution of tomato ringspot virus in DeChaunac vineyards in the Niagara Peninsula. Plant Disease Reporter, 61(1):24-28

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses.* Elsevier Academic Press, London, UK; 1259 pp.

Forer LB, Powell CA, Stouffer RF (1984) Transmission of tomato ringspot virus to apple rootstock cuttings and to cherry and peach seedlings by *Xiphinema rivesi*. Plant Disease 68: 1052-1054

Freeman JA, Stace-Smith R, Daubeny HA, 1975. Effects of tomato ringspot virus on the growth and yield of red raspberry. Canadian Journal of Plant Science, 55(3):749-754

Hibben CR, Reese JA, 1983. Identification of tomato ringspot virus and mycoplasma-like organisms in stump sprouts of ash. Phytopathology, 73:367.

ICTVdB Management (2006) 00.018.0.03.029. Tomato ringspot virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA; at http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.018.0.03.029.htm

Jones, A L; Aldwinckle, H S (1990) *Compendium of apple and pear diseases.* American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

Knight K W L; Barber C J; Page G D (1997) Plant-parasitic nematodes of New Zealand recorded by host association. *Supplement to the Journal of Nematology* 29 (4S) : 640-656.

Pearson M N; Clover G R G; Guy P L; Fletcher J D; Beever R E (2006) *A review of the plant virus, viroid and mollicute records for New Zealand.* Australasian Plant Pathology 35 (2): 217-252

PPIN (Year of search) Plant Information Network. MAF database.

Stouffer, R. F. and Uyemoto, J. K. 1976. Association of tomato ringspot virus with apple necrosis virus and decline. Acta Horticulturae 67:203-208.

Sturhan D; Wouts W M; Grandison G S; Barber C J (1997) Nematode vectors of plant viruses in New Zealand. *New Zealand Journal of Zoology* 24: 309-322.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures); at http://nrsp5.prosser.wsu.edu/index.html.

5.9. Tulare apple mosaic virus (TAMV)

5.9.1. Hazard identification

5.9.1.1. Aetiologic agent

Tulare apple mosaic virus (TAMV), Family: *Bromoviridae*, Genus: *Ilarvirus* (Brunt *et al*. 1996, ICTVdB Management 2006).

5.9.1.2. New Zealand status

TAMV has not been recorded in New Zealand (Pearson *et al.* 2006, PPIN 2009).

5.9.1.3. Biology and epidemiology

First reported in *Malus sylvestris*, from the USA, TAMV was isolated from a single apple tree (since removed) in Tulare County, California, and later from *Corylus avellana* (hazel) in France (Brunt *et al*. 1996). These are the only recorded natural hosts to date while several (3-9) families have been shown to be susceptible experimentally (Brunt *et al*. 1996). Leaves have been recorded as developing severe symptoms similar to those of the more common apple mosaic virus. Patterns often appear on veins and adjacent tissues and spots are not sharply delineated, but are spread irregularly along the veins. Fruits develop no diagnostic symptoms in most apple cultivars tested (WSU 2003). TAMV is reported to be transmitted by mechanical inoculation (Mink & Bancroft 1962) but not by seed (Brunt *et al*. 1996).

5.9.1.4. Hazard identification conclusion

The accepted absence of TAMV in New Zealand, the potential ability of *Malus* nursery stock to host this virus, and its ability to cause disease symptoms on commercial plants in New Zealand all suggest that TAMV should be considered a potential hazard requiring further assessment.

5.9.2. Risk assessment

5.9.2.1. Entry assessment

There is very little information available about the distribution or occurrence of TAMV internationally. This may in part be due to the similarity between observed symptoms of TAMV and those of other apple diseases such as Apple Mosaic Virus. Had the only record of TAMV been that found on the single tree in California the conclusion could reasonably have been drawn that the virus has now been eradicated. The second record in France suggests that TAMV may be more widespread than has been recorded.

Given the uncertainty about the occurrence of TAMV in *Malus* internationally, and the potential that this virus may be more widely distributed than has been recorded, the likelihood of entry should be considered non-negligible.

5.9.2.2. Assessment of exposure and establishment

Should this virus be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

5.9.2.3. Consequence assessment

Spread

There is little information on how TAMV is distributed within a population of host plants. Detection of the virus in California, USA, and France suggests that at the very least the virus can spread through the movement of germplasm (Brunt *et al*. 1996).

Economic consequences

There is little information available on the impacts of TAMV on the cultivars used in horticulture in New Zealand. Should the virus produce significant disease effects on important cultivars in New Zealand the economic impact would be expected to be limited to production only, with market access (exports) unaffected beyond potential supply issues. The potential economic impact of TAMV on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by TAMV, namely localised leaf necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by TAMV lowering fruit yield or quality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand. The potential environmental impact of TAMV in New Zealand should therefore be considered to have a low likelihood of being low.

Human Health consequences

TAMV is not known to be of any significance to human health.

5.9.2.4. Conclusion of consequence assessment

From the assessment above it is possible to conclude that TAMV has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

5.9.2.5. Risk estimation

The risk of TAMV being introduced into New Zealand with *Malus* budwood and causing unwanted impacts is considered low and as such non-negligible, mainly due to the lack of available information on this disease agent. However, the above risk estimation is subject to review when further information on distribution, biology and impact become available.

5.9.2.6. Assessment of uncertainty

There is considerable uncertainty around the taxonomy, biology, distribution and epidemiology of this virus. As such this risk assessment should be reviewed once further relevant information becomes available.

5.9.3. Risk management

5.9.3.1. Risk evaluation

Since the risk estimate for TAMV associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

5.9.3.2. Option evaluation

There are conceivably a number of management options available for TAMV on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of TAMV;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of TAMV;
- **d.** Virus indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

The level of assessed risk from TAMV is non-negligible mainly due to the lack of available information on this disease agent. This risk analysis recognises that given the level of uncertainty around the epidemiology of TAMV the low level of associated biosecurity risk may be considered acceptable.

Pest free area (PFA)

Given the paucity of information available on the epidemiology of TAMV it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFA determination could be obtained. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

Given the paucity of information available on the epidemiology of TAMV it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFPP determination could be obtained. A PFPP declaration for TAMV should not therefore be considered an effective phytosanitary measure under current circumstances.

Virus indexing of mother plants

While there is no specific virus indexing method documented for TAMV, mechanical inoculation tests from the mother plants onto susceptible host material such as *Nicotiana tabacum* or *Phaseolus vulgaris* cv. 'Bountiful' should ensure disease symptoms become apparent (CPC 2007). Diagnostic symptoms on these hosts include local necrotic lines and rings with systemic necrotic rings and oak-leaf patterns on new leaves while later formed leaves are symptomless (*Nicotiana tabacum*) and brown local lesions on leaves without systemic infection (*Phaseolus vulgaris* cv. 'Bountiful') (CPC 2007, ICTVdB Management 2006). Inoculation of herbaceous indicators can be followed by ELISA or PCR testing of symptomatic material.

There is currently no information on the reliability of mechanical inoculation of TAMV infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. To reduce the likelihood of false negatives the inoculation test should be repeated again the following season. The two-test schedule described here should be considered an effective phytosanitary measure against TAMV (see section 4.3.1 for more discussion).

Inspection of mother plants

Relying on the detection of TAMV infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against TAMV.

5.9.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Brunt A A, Crabtree K, Dallwitz M J, Gibbs A J, Watson L, Zurcher E J (eds.) (1996 onwards). *Plant Viruses Online: Descriptions and Lists from the VIDE Database*. Available at: http://image.fs.uidaho.edu/vide/

ICTVdB Management (2006) 00.010.0.02.018. Tulare apple mosaic virus. In: *ICTVdB - The Universal Virus Database*, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA; at http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.010.0.02.018.htm

Mink G I, Bancroft J B (1962) Purification and Serology of Tulare Apple Mosaic Virus. *Nature* 194, 214 - 215

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures); at http://nrsp5.prosser.wsu.edu/index.html.

6. Risk analyses – Viroids

6.1. Apple dimple fruit viroid (ADFVd)

6.1.1. Hazard identification

6.1.1.1. Aetiologic agent

Apple dimple fruit viroid (ADFVd), Family: *Pospivoidae*, Genus: *Apscaviroid*

6.1.1.2. New Zealand status

ADFVd is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

6.1.1.3. Biology and epidemiology

ADFVd induces visible symptoms on apple fruits, consisting of depressed yellow-green spots of 3-4 mm in diameter. In some cases, the spots are concentrated around the calyx and may coalesce into large discoloured areas. Other plant organs remain symptomless. Under natural or experimental conditions, ADFVd symptoms have been observed on the following cultivars of *Malus domestica*: 'Starking Delicious', 'Annurca', 'Starkrimson', 'Royal Gala', 'Pink Lady' and 'Braeburn'. Fruits of cv. 'Braeburn' may also exhibit scar skin symptoms. ADFVd infections of cultivars 'Golden', 'Golden Delicious', 'Smoothee', 'Granny Smith', 'Baujade' and 'Reinette Grise du Canada' can be symptomless. Typical fruit symptoms on symptomatic cultivars (such as 'Starkrimson' and 'Braeburn') can be observed 2-3 years post inoculation (WSU 2003, CPC 2007, Saerio *et al.* 2003).

Extensive necrotic areas of the flesh underlying skin depressions and rusty skin have been observed on ADFVd-infected fruits of *M. domestica* cvs 'Starking Delicious' and 'Golden Delicious', respectively. The origin of these symptoms, however, has not been ascertained (CPC 2007).

Epidemiology

Circular RNA forms of ADFVd are infectious (CPC 2007). ADFVd is recorded as being graft transmitted (WSU 2003). In seedlings mechanically inoculated by slashing, and grown in a greenhouse, viroid accumulation reached detectable levels in 10 months. ADFVd is able to replicate autonomously in apple and pear plants, but symptom expression was only observed in apple. Co-existence in the same host of apple scar skin viroid (ASSVd) and ADFVd does not seem to have any effect on symptom expression and viroid accumulation (CPC 2007, Saerio *et al.* 2003). ADFVd is unlikely to be transmitted by seed (Saerio *et al.* 2003).

ADFVd is recorded as being present in Italy and South Africa (CPC 2007, BA 2002), but may have a wider distribution given the asymptomatic nature of some potential hosts.

Hosts

Natural infections of ADFVd have been reported only from apple (Saerio *et al.* 2003). However, because the viroid has only been known for a few years and has been experimentally transmitted to pear cv. 'Freud 37', it is likely that the natural host range is wider (CPC 2007, Anonymous 1970, Saerio *et al.* 2003).

6.1.1.4. Hazard identification conclusion

The accepted absence of ADFVd in New Zealand, the ability of this viroid to be vectored by *Malus* nursery stock, and its ability to cause commercially important disease symptoms in

New Zealand all suggest that ADFVd should be considered a potential hazard requiring further assessment.

6.1.2. Risk assessment

6.1.2.1. Entry assessment

There is little available information on the prevalence of this viroid within infected *Malus* populations. The likelihood of the association of ADFVd with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. As with any viroid, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of ADFVd into New Zealand with *Malus* nursery stock from infected populations is low to moderate and therefore non-negligible.

6.1.2.2. Assessment of exposure and establishment

Should ADFVd be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

6.1.2.3. Consequence assessment

Spread

Plant parts liable to carry the pest in trade/transport include fruit, flowers, leaves, roots and stems (CPC 2007), however only planting material would act as a vehicle for spread within New Zealand. The virus can also be spread mechanically by slashing (CPC 2007). There are no known vectors or other means of spread of ADFVd. As hosts may remain asymptomatic, detection and containment measures against spread are likely to be difficult. It is therefore considered that the likelihood of spread is low to moderate.

Economic consequences

Malus fruit (apples) showing symptoms have no commercial value. The effect of ADFVd infection on the yield of asymptomatic varieties remains unknown (CPC 2007). There is likely to be impact on the (future) export market of apples should ADFVd establish in New Zealand as this viroid is deemed a quarantine pathogen in Australia (BA 2002). *Malus* cultivars that are important commercially in New Zealand and are known to be symptomatic of ADFVd include 'Royal Gala' and 'Braeburn'. The potential economic impact of ADFVd on the New Zealand horticultural sector should therefore be considered to have a moderate likelihood of being moderate to high.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus, Acena, Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by ADFVd, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by ADFVd lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of ADFVd in New Zealand should therefore be considered to have a low likelihood of being low.

Human Health consequences

This organism is not known to be of any significance to human health.

6.1.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that ADFVd has a moderate likelihood of causing moderate to high economic consequences and a low likelihood of low environmental consequences to New Zealand.

6.1.2.5. Risk estimation

The likelihood estimate is low that ADFVd would be associated with *Malus* nursery stock on entry into New Zealand, high that any ADFVd that does enter would successfully establish in New Zealand, moderate that the establishment would result in moderate to high economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for ADFVd associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

6.1.2.6. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this viroid. As such this risk assessment should be reviewed once further relevant information becomes available.

6.1.3. Risk management

6.1.3.1. Risk evaluation

Since the risk estimate for ADFVd associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

6.1.3.2. Option evaluation

There are conceivably a number of management options available for ADFVd on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ADFVd;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ADFVd;
- **d.** Viroid indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Visual examination of fruits may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It has been shown that ADFVd infection induces no symptoms in several apple cultivars. Moreover, a latent period of 2-3 years elapses between inoculation and symptom expression in symptomatic varieties. It therefore should be considered likely that a reliable PFA determination may not be able to be obtained. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, due to the unreliable expression of symptoms it should be considered likely that a reliable PFPP determination may not be able to be obtained. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Viroid indexing of mother plants

ADFVd is thought to be readily transmitted by grafting to woody indicator plants (CPC 2007). Potential woody indicator plants with diagnostic symptoms include the *Malus domestica* cultivars 'Starking Delicious', 'Annurca', 'Starkrimson', 'Royal Gala', 'Pink Lady' and 'Braeburn'. Typical fruit symptoms appear 2-3 years after graft-inoculation.

Since reaction of these varieties may not clearly distinguish ADFVd from apple scar skin viroid (ASSVd), molecular tests are needed for conclusive diagnosis. A dot-blot hybridization method based on dioxygenine-labelled full-length cRNA probes specific for ADFVd has been developed. Reverse transcription polymerase chain reaction (RT-PCR) using ASSVd- and ADFVd-specific primers should also discriminate between the two pathogens (CPC 2007, Saerio *et al.* 2003).

There is currently no information on the reliability of mechanical inoculation of ADFVd infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, viroid indexing should be considered an effective phytosanitary measure against ADFVd.

Inspection of mother plants

As ADFVd is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of ADFVd (e.g. the *Malus domestica* cultivars 'Starking Delicious', 'Annurca', 'Starkrimson', 'Royal Gala', 'Pink Lady' and 'Braeburn'). Assuming symptomatic (fruiting) mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against ADFVd.

6.1.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Anonymous (1970) Annual Report, East Mailing Research Station, 1969. (1st Oct. 1968-30th Sept. 1969).

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

CPC (2007) *Crop Protection Compendium on Internet.* CAB INTERNATIONAL, Wallingford, UK; http://www.cabi.org/compendia/CPC/

NAPPO (2004) *Guidelines for* International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and *Xylella fastidiosa*. NAPPO (North American Plant Protection Organisation) *Regional Standards for Phytosanitary Measures* (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

Serio F di, Malfitano M, Alioto D, Ragozzino A, Flores R (2003) Apple dimple fruit viroid. In Hadidi A, Flores R, Randles J W, Semancik J S (Eds) *Viroids.* CSIRO Publishing; pgs 146-149.

WSU (2003) *"Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

6.2. Apple fruit crinkle viroid (AFCVd)

6.2.1. Hazard identification

6.2.1.1. Aetiologic agent

Apple fruit-crinkle viroid (AFCVd), tentatively listed as a species in the genus *Apscaviroid* (Fauquet *et al*. 2005).

6.2.1.2. New Zealand status

AFCVd is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009).

6.2.1.3. Biology and epidemiology

AFCVd was initially discovered in Japan in 1976 on apple cultivar 'Mutsu' (Crispin), where fruit symptoms are most severe on the apple cultivar 'Ohrin', and later as a bark disorder on apple cultivar 'Nero 26' (Koganezawa *et al.* 2003). Pear and hops are also reported to be hosts (BA 2002, Koganezawa *et al.* 2003, Nakaune & Nakano 2008) and a similar (91.4-96.3% sequence) viroid was detected in persimmon (Sano *et al.* 2008).

Symptoms of natural infection in apple develop in mature fruit, the most apparent of these being depressions and malformation (crinkling) in addition to variations in colour (dappling) of the fruit surface. The crinkling symptoms appear near maturity and seem to be less severe in cool summers. The dappling symptoms of the disease resemble those caused by Apple Scar Skin viroid (ASSVd). The severity of these symptoms varies among apple cultivars 'Ohrin', 'Mutsu', 'Hokuto', 'Senshu', 'Jonathan', 'Fuji', 'Tsugaru', 'Sansa', 'Yoko' and 'Blaxstayman'. The cultivar 'Ohrin' appears to exhibit the most serious deformation with scattered brown necrotic areas in the fruit flesh (WSU 2005, Koganezawa *et al.* 2003). Fruit symptoms become obvious in the middle of August (late summer) and clearer near apple harvesting time (Koganezawa *et al.* 2003). Bark symptoms may also appear on two to three year old shoots in cultivars such as 'Starking Delicious', 'Nero 26', 'Winesap' and crab apple cultivar 'NY58-22' (Grove *et al*. 2003, Koganezawa *et al.* 2003). Apple cultivars 'Indo' and 'Spartan' are symptomless. Shoots and roots are generally less vigorous on infected trees (Koganezawa *et al.* 2003).

AFCVd is recorded as being graft transmitted with a 2-3 year latent period found for fruit symptoms in experiments, and longer for bark symptoms (Grove *et al*. 2003, Koganezawa *et al.* 2003). AFCVd is also easily transmitted by budding, chip budding and slashing. No natural vector has been observed to date (Koganezawa *et al.* 2003).

AFCVd and is considered present in Japan (BA 2002) but may be more widely distributed given the potential for symptoms to be masked by other diseases of *Malus* such as those caused by ASSVd (WSU 2005).

6.2.1.4. Hazard identification conclusion

The accepted absence of AFCVd in New Zealand, the ability of this viroid to be vectored by *Malus* nursery stock, and its potential ability to cause commercially important disease symptoms in New Zealand all suggest that AFCVd should be considered a potential hazard requiring further assessment.

6.2.2. Risk assessment

6.2.2.1. Entry assessment

There is little available information on the prevalence of this viroid within infected *Malus* populations. The likelihood of the association of AFCVd with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. As with any viroid, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of AFCVd into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

6.2.2.2. Assessment of exposure and establishment

Should AFCVd be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

6.2.2.3. Consequence assessment

Spread

The available information on the epidemiology of this viroid is limited. There are no known vectors or other means of spread except by assisted means. It is therefore considered that the likelihood of spread is low.

Economic consequences

As the symptoms develop in mature fruit, the quality of the fruits would be affected. No report on impact on yield is available. Should the viroid become established, nursery export markets could be affected as Biosecurity Australia considers apple fruit crinkle to be a quarantine pathogen (BA 2002). The potential economic impact of AFCVd on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by AFCVd, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by AFCVd lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of AFCVd in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

This organism is not known to be of any significance to human health.

6.2.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that AFCVd has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

6.2.2.5. Risk estimation

The likelihood estimate is low that AFCVd would be associated with *Malus* nursery stock on entry into New Zealand, high that any AFCVd that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for AFCVd associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

6.2.2.6. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this viroid. As such this risk assessment should be reviewed once further relevant information becomes available.

6.2.3. Risk management

6.2.3.1. Risk evaluation

Since the risk estimate for AFCVd associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

6.2.3.2. Option evaluation

There are conceivably a number of management options available for AFCVd on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of AFCVd;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of AFCVd;
- **c.** Viroid indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

Given the paucity of information available on the epidemiology of AFCVd it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFA determination could be obtained.

Pest free place of production (PFPP)

As with PFA above, given the paucity of information available on the epidemiology of AFCVd it does not seem likely that, in the absence of a reliable low cost method for detecting and identifying the presence of this virus, a reliable PFPP determination could be obtained.

Viroid indexing of mother plants

AFCVd can be detected by woody indexing on the apple cultivars ‘Delicious’ or, preferably, ‘NY5822’, where it induces symptoms of blister bark (Grove *et al*. 2003, Koganezawa *et al.* 2003). Sampling and laboratory testing (RT-PCR) would then be required to confirm the identity of the causal agent as AFCVd.

There is currently no information on the reliability of mechanical inoculation of AFCVd infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, viroid indexing should be considered an effective phytosanitary measure against AFCVd.

Inspection of mother plants

As AFCVd is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of AFCVd (e.g. the *Malus* cultivars 'Delicious' or 'NY5822'). Assuming symptomatic mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against AFCVd.

6.2.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (Pyrus) Budwood. Biosecurity Australia; 68pp.

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (eds) (2005) Virus Taxonomy: Classification and Nomenclature of Viruses. Eighth Report of the International Committee on the Taxonomy of Viruses. Elsevier Academic Press; London, UK; 1259 pp.

Grove, G G; Eastwell, K C; Jones, A L; Sutton, T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (eds) Apples: Botany, Production and Uses. CAB International; 459-579.

Koganezawa H, Ito T (2003) Apple fruit crinkle viroid. In Hadidi A, Flores R, Randles J W, Semancik J S (Eds) *Viroids*. CSIRO Publishing; pgs 150-152.

Nakaune, R., Nakano, M. (2008) Identification of a new *Apscaviroid* from Japanese persimmon. *Archives of Virology* 153; pgs 969-972.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

Sano T, Isono S, Matsuki K, Kawaguchi-Ito Y, Tanaka K, Kondo K, Iijima A, Bar-Joseph M (2008) Vegetative propagation and its possible role as a genetic bottleneck in the shaping of the apple fruit crinkle viroid populations in apple and hop plants. *Virus Genes* 37: pgs 298-303.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

6.3. Apple scar skin viroid (ASSVd)

6.3.1.1. Aetiologic agent

Apple Scar Skin viroid (ASSVd), Family: *Pospiviroidae*, Genus: *Apscaviroid* (Fauquet *et al*. 2005)

Listed strains and/or synonyms include (Fauquet *et al*. 2005):

- Apple Scar Skin viroid (ASSVd)
- Apple Scar Skin viroid - dapple (Dapple apple viroid) (ASSVd -dap)
- Apple Scar Skin viroid - Japanese pear (Japanese pear fruit dimple viroid) (ASSVd -jpf)
- Apple Scar Skin viroid – pear rusty skin (Pear rusty skin viroid) (ASSVd -prs)

6.3.1.2. New Zealand status

ASSVd has not been reported in New Zealand (Pearson *et al.* 2006, PPIN 2009)

6.3.1.3. Biology and epidemiology

Apple Scar Skin disease was first reported as Manchurian apple ‘Sabika’ disease from China around 1935. Apple dapple disease, which was first described in the 1950s from the USA, is considered to be caused by a variant of ASSVd (Koganezawa *et al.* 2003).

The symptoms of ASSVd in apple are usually found at the calyx end of the fruit, and include scar skin (reddish brown patches with brownish scar-like tissue), cracking, or dapple (spotting). Infected fruits often remain small and hard, do not ripen properly, and develop an unpleasant off-flavour. Almost all fruit on an infected tree of a susceptible cultivar will show symptoms and are unmarketable. Dapple symptoms, which develop nearer to harvest, usually appear on the red-skinned cultivars (e.g. ‘Jonathan’, ‘Red Gold’). Scar skin is more common on cultivars ‘Ralls Janet’ and ‘Indo’, and both types of symptoms can occur on ‘Starking Delicious’ and ‘Red Delicious’. In the susceptible cultivar ‘Indo’, scars can eventually cover more than 50% of the fruit surface. On cultivar ‘Ralls Janet’, water-soaked blotches appear first, followed by scar tissue, and then cracking. Fruits of cultivar ‘Ohrin’ express green depressed spots with fresh necrosis that resembles other viroid diseases. Scar skin symptoms often become more pronounced each year, while the opposite occurs with dapple symptoms (Németh 1986, CPC 2007, Koganezawa *et al.* 2003). Diseased fruit are significantly smaller than fruit from uninfected trees (Grove *et al*. 2003).

Although symptoms of ASSVd are usually confined to the fruit and do not show pronounced leaf or bark symptoms, under certain conditions some apple cultivars (e.g. ‘Stark’s Earliest’, ‘Sugar Crab’, Ralls Janet’) may develop leaf roll or leaf epinasty symptoms (Grove *et al*. 2003, CPC 2007). The severity of the disease depends on the apple cultivars affected, with ‘Golden Delicious’ and ‘Granny Smith’ being considered relatively tolerant (Koganezawa *et al.* 2003).

Epidemiology

In terms of human movement, ASSVd spreads through budding and grafting from infected plants. The incubation period is 2-3 years (Jones & Aldwinckle 1990, Németh 1986). While the viroid has been detected in apple and pear seed samples, it has not been shown to be seed-transmitted (Howell *et al.* 1997). Similarly, there is no evidence of seed-transmission in oriental pear (CPC 2007).

No insect vector is known, but root grafts may lead to some slow field spread. In parts of Greece the viroid has been found in wild pear in isolated areas, suggesting that there may be some means of natural transmission (CPC 2007).

ASSVd has been recorded as being present in Asia (China, India, Iran, Japan, Republic of Korea, Turkey), Europe (Denmark, Greece, Italy, Poland, United Kingdom), and North America (Canada, USA) (CPC 2007, Koganezawa *et al.* 2003), but is likely to be more widely distributed. Postman pers. com. (2008) considers ASSVd is no longer established in North America.

Hosts

Natural infections of ASSVd have been recorded on *Malus domestica* (apple), *Pyrus amygdaliformis, Pyrus bretschneideri, Pyrus communis* (European pear), *Pyrus pyrifolia* (Oriental pear tree), and *Pyrus ussuriensis* (CPC 2007, Fauquet *et al*. 2005). All species of *Malus* and *Pyrus* are likely to act as hosts of ASSVd, although many (especially *Pyrus* species) will be symptomless (Koganezawa *et al.* 2003).

6.3.1.4. Hazard identification conclusion

The accepted absence of ASSVd in New Zealand, the ability of this viroid to be vectored by *Malus* nursery stock, and its ability to cause commercially important disease symptoms in New Zealand all suggest that ASSVd should be considered a potential hazard requiring further assessment.

6.3.2. Risk assessment

6.3.2.1. Entry assessment

ASSVd is believed to be native to and widespread in East Asia, and is present, although rare, in many other parts of the world, such as North America and Europe (CPC 2007). However, as the viroid can be latent in some apple and many pear cultivars, it could be more widely distributed than the literature suggests, particularly in older plantings (CPC 2007). Plant parts liable to carry the pest in trade and transport include the leaves, stems, shoots, trunks, branches and wood, all of which bear the disease internally and no symptoms are visible (CPC 2007).

It is therefore considered that the likelihood of entry of ASSVd into New Zealand with *Malus* nursery stock from infected populations is low to moderate and therefore non-negligible.

6.3.2.2. Assessment of exposure and establishment

Should ASSVd be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

6.3.2.3. Consequences

Spread

The hosts of ASSVd, namely apples and pears, are readily available throughout New Zealand. The genus of ASSVd, Apscaviroid, is reported worldwide (Fauquet *et al*. 2005), which suggests climate is unlikely to become a constraining factor. ASSVd can be spread by human activities through budding and grafting and there may be natural means to assist the spread of ASSVd. However, at present no vector is known that transmits ASSVd. The likelihood of the spread of ASSVd after establishment is therefore considered moderate.

Economic consequences

Apple scar skin disease caused serious economic losses in China in the 1950s and Japan in the 1960s and 70s (Koganezawa *et al.* 2003). In sensitive cultivars, such as the New Zealand grown cultivar 'Red Delicious', infection with ASSVd causes significant reductions in fruit size and quality. Usually the entire crop from ASSVd -affected trees is unmarketable (CPC 2007, Koganezawa *et al.* 2003). The potential economic impact of ASSVd on the New Zealand horticultural sector should therefore be considered to have a moderate likelihood of being moderate to high.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by ASSVd, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by ASSVd lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of ASSVd in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

This organism is not known to be of any significance to human health.

6.3.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that ASSVd has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

6.3.2.5. Risk estimation

The likelihood estimate is low to moderate that ASSVd would be associated with *Malus* nursery stock on entry into New Zealand, high that any ASSVd that does enter would successfully establish in New Zealand, and moderate that the establishment would result in moderate to high economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for ASSVd associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

6.3.2.6. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this viroid. As such this risk assessment should be reviewed once further relevant information becomes available.

6.3.3. Risk management

6.3.3.1. Risk evaluation

Since the risk estimate for ASSVd associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

6.3.3.2. Option evaluation

There are conceivably a number of management options available for ASSVd on imported *Malus* nursery stock. The following risk management options are assessed:

a. Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ASSVd;

b. Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ASSVd;

c. Viroid indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.

d. Inspection of mother plants.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination of fruits may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It has been shown that ASSVd infection induces no symptoms in several apple cultivars. Moreover, a latent period of 2-3 years can elapse between inoculation and symptom expression in symptomatic varieties. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, due to the unreliable expression of symptoms it should be considered unlikely that a reliable PFPP determination could be obtained. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Viroid indexing of mother plants

ASSVd has not been mechanically transmitted to herbaceous plant species. Woody indexing (i.e. graft transmission to a fruiting apple tree) is a good detection technique but requires an incubation period of up to 3 years (Németh 1986). The pathogen can also be detected in bark tissues of affected apple trees by gel electrophoretic assay 1-2 years after inoculation (CPC 2007).

The *Malus domestica* cultivar 'Sugar Crab' may be a useful indicator because, when infected, it develops deep cracks in the fruit which suberize and become dark brown or black in colour (Németh 1986). Other useful indicators include cultivars 'Indo', 'Ralls Janet', 'Starkrimson', 'Starking Delicious', 'Red Delicious' and 'Virginia Crab'. The crab apples 'NY11894' and 'Shui Hong Se Ping Guo' are also suitable (CPC 2007, Koganezawa *et al.* 2003).

In terms of more rapid diagnostic methods, leaf epinasty symptoms can be induced in double-bud inoculated apple trees of 'Stark's Earliest' and 'Sugar Crab' within 2 months if maintained for 24-hour photoperiods in growth chambers at 18°C or 28°C (CPC 2007, Koganezawa *et al.* 2003).

Molecular techniques have also been developed, with the advantage of being both reliable and fast. Both RT-PCR and hybridization assays are used for ASSVd (Grove *et al*. 2003, Koganezawa *et al.* 2003).

There is currently no information on the reliability of mechanical inoculation of ASSVd infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, viroid indexing should be considered an effective phytosanitary measure against ASSVd. Use of the more rapid leaf epinasty diagnostic method in 24-hour photoperiods at 18°C or 28°C should be repeated to reduce the likelihood of false negatives (see section 4.3.1 for more discussion). A repeated rapid test described here should be considered an effective phytosanitary measure against ASSVd.

Inspection of mother plants

As ASSVd is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of ASSVd (e.g. the *Malus* cultivars 'Sugar Crab', 'Indo', 'Ralls Janet', 'Starkrimson', 'Starking Delicious', 'Virginia Crab', 'NY11894' and 'Shui Hong Se Ping Guo'). Assuming symptomatic mother plants are inspected over a 4-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against ASSVd.

6.3.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

CPC (2005) *Crop Protection Compendium on Internet.* CAB INTERNATIONAL, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (eds) (2005) *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses.* Elsevier Academic Press, London, UK; 1259 pp.

Grove G G, Eastwell K C, Jones A L, Sutton T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (eds) *Apples: Botany, Production and Uses.* CAB International; 459-579.

Howell W E, Skrzeczkowski L J, Wessels T, Mink G I, Nunez A (1998) Non-transmission of apple scar skin viroid and peach latent mosaic viroid through seed. *Acta Horticulturae* 472, pgs 635-639.

Jones, A L; Aldwinckle, H S (ed) (1990) *Compendium of apple and pear diseases.* American Phytopathological Society Press; St. Paul, Minnesota, USA.

Koganezawa H, Yang X, Zhu S F, Hashimoto J, Hadidi A (2003) Apple scar skin viroid in apple. In Hadidi A, Flores R, Randles J W, Semancik J S (Eds) *Viroids*. CSIRO Publishing; pgs 137-141.

NAPPO (2004) *Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and* Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) *Virus, mycoplasma and rickettsia diseases of fruit trees.* Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

6.4. Peach latent mosaic viroid (PLMVd)

6.4.1. Hazard identification

6.4.1.1. Aetiologic agent

Peach Latent Mosaic viroid (PLMVd), Family: *Avsunviroidae*, Genus: *Pelamoviroid* (CPC 2007, Fauquet *et al*. 2005).

Listed strains and/or synonyms include (Fauquet *et al*. 2005):

- Peach latent mosaic viroid
- Peach latent mosaic viroid – apple
- Peach latent mosaic viroid – apricot
- Peach latent mosaic viroid – cherry
- Peach latent mosaic viroid – pear
- Peach latent mosaic viroid – plum

6.4.1.2. New Zealand status

PLMVd is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

6.4.1.3. Biology and epidemiology

PLMVd was originally described in France in 1976 (Desvignes 1976). The disease is often latent in peach trees but may induce mosaic symptoms on leaves, irregularly shaped colourless fruit with cracked sutures and enlarged pits, bud necrosis, and delay in foliation, flowering and fruit maturity (Faggioli *et al*. 1997). The reported isolation of PLMVd used apple and pear fruits and bark showing canker symptoms, symptoms of scab and streak (El Dougdoug 1998).

Epidemiology

In the European and Mediterranean area, the viroid is probably generally transmitted over 5 to 20 metres by an aerial vector such as *Myzus persicae*. The annual rate of transmission is about 5% to any *Prunus* tree adjacent to an infected tree (Desvignes 1986). PLMVd is not transmitted by pollen or by mites, but in greenhouse conditions it has been successfully transmitted to peach by the aphid *Myzus persicae* (CPC 2007). PLMVd has not been found to be seed transmitted (CPC 2007). PLMVd was found to be readily mechanically transmitted on contaminated knife blades to 50-70% of green shoots and lignified stems of peach GF-305 plants. It is therefore suggested that PLMVd is transmitted in orchards by contaminated pruning equipment. Total infection of 3- to 20-year-old *Prunus* trees is only complete 3-5 years after inoculation of an external young shoot (CPC 2007). Dissemination over long distances is favoured by the distribution of viroid-infected propagation material and is considered the main epidemic source of PLMVd infection (CPC 2007). Plant parts liable to carry the pest in trade or transport include the fruits, flowers, leaves, roots, stems, shoots, trunks and branches, all of which are borne internally and invisible (CPC 2007).

PLMVd appears to be restricted to its natural hosts and very closely related species, but other reports indicate that PLMVd naturally infects additional species within and outside the genus *Prunus* (Desvignes 1986, Fauquet *et al*. 2005). Several strains have been identified to affect peach, apricot, cherry, plum, apple and pear (Fauquet *et al*. 2005, Hadidi *et al*. 2003). PLMVd infected apple plants have only been sporadically detected in commercial orchards of apple and pear in Egypt, and the published identification has been tentative (El Dougdoug 1998). El Dougdoug (1998) noted that "*Analysis by southern and dot blot hybridisation suggested that the disease agent shares similarities in sequence with peach latent mosaic viroid*". Desvignes

(1986) noted that the describe symptoms on apricot, almond and plum (chlorotic rings or patterns) are not typical of PLMVd.

PLMVd has been detected in 25% of peach cultivars coming from Europe, USA, China and Japan. PLMVd is thus probably distributed more widely in peach-growing areas.

6.4.1.4. Hazard identification conclusion

Given the wide international distribution of PLMVd on peach, the ease of mechanical transmission, and the lack of any records on *Malus* outside of the tentative record in Egypt, it is either unlikely that *Malus* is a host of PLMVd or that strains present only in Egypt can infect *Malus* plants growing within infected pear orchards. While there is a degree of uncertainty in these assumptions PLMVd should not be considered a potential hazard and as such should not require further assessment.

6.4.1.5. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this viroid. As such this risk assessment should be reviewed once further relevant information becomes available.

6.4.2. References

BA (2002). Biosecurity Australia. Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (Pyrus) Budwood.

CPC (2005) Crop Protection Compendium on Internet. CAB INTERNATIONAL, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Desvignes JC (1976) The virus diseases detected in greenhouse and field by peach seedlings GF-305 indicator. Acta Horticulturae (67): 315-323.

El Dougdoug, K A (1998) Occurrence of peach latent mosaic viroid in apple (*Malus domestica*). Annals of Agricultural Science Cairo 43(1): 21-30.

Faggioli F, Loreti S, Barba M (1997) Occurrence of peach latent mosaic viroid (PLMVd) on plum in Italy. Plant Disease 81(4): 423.

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses. Elsevier Academic Press, London, UK; 1259 pp.

Hadidi A, Giunchedi L, Osaki H, Shamloul A M, Crescenzi A, Gentit P, Nemchinov L, Piazzolla P, Kyriakopoulou P E (2003) Peach latent mosaic viroid in temperate fruit hosts. In Hadidi A, Flores R, Randles J W, Semancik J S (Eds) *Viroids*. CSIRO Publishing; pgs 161-164.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

7. Risk analyses - Phytoplasma

7.1. *Candidatus* Phytoplasma *asteris* (ApSL)

7.1.1. Hazard identification

7.1.1.1. Aetiologic agent

Candidatus Phytoplasma *asteris* or Apple sessile leaf (ApSL) phytoplasma, is a member of the 16SrI-B '*Candidatus* Phytoplasma asteris' subgroup (Jomantiene & Davis 2005).

7.1.1.2. New Zealand status

ApSL is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

7.1.1.3. Biology and epidemiology

ApSL is a new disease of apple (*Malus domestica*) recorded from Lithuania (Jomantiene & Davis 2005). The phytoplasma causes leaf yellowing, shoot proliferation and a previously undescribed symptom 'sessile leaf', in which 'golden' leaves are directly attached to the trunk (Jomantiene & Davis 2005). There are no reports of ApSL in other areas or other species or cultivars of *Malus*.

7.1.1.4. Hazard identification conclusion

The accepted absence of ApSL in New Zealand, the ability of this phytoplasma to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that ApSL should be considered a potential hazard requiring further assessment.

7.1.2. Risk assessment

7.1.2.1. Entry assessment

There is little available information on the prevalence of this phytoplasma within infected *Malus* populations. The likelihood of the association of ApSL with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. As with any phytoplasma, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of ApSL into New Zealand with *Malus* nursery stock from infected populations is low to moderate and therefore non-negligible.

7.1.2.2. Assessment of exposure and establishment

Should ApSL be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

7.1.2.3. Consequence assessment

Spread

There is no information on how ApSL is spread through infected populations of *Malus*. It is likely that plant parts such as fruit, flowers, leaves, roots and stems are liable to carry the pest in trade/transport. It is therefore considered that the likelihood of spread is low to moderate.

Economic consequences

While symptoms are described on leaves and shoots, it is not certain how the phytoplasma affects the productivity of the fruit trees. However, Jomantiene and Davis (2005) commented that this first report of "*Candidatus* Phytoplasma asteris" infecting apple in Lithuania has considerable significance for fruit production, as apple is widely cultivated throughout Europe. The potential economic impact of ApSL on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by ApSL, namely localised leaf necrosis or shoot poliferation, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by ApSL lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of ApSL in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

This organism is not known to be of any significance to human health.

7.1.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that ApSL has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

7.1.2.5. Risk estimation

The likelihood estimate is low that ApSL would be associated with *Malus* nursery stock on entry into New Zealand, high that any ApSL that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for ApSL associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

7.1.2.6. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this phytoplasma. As such this risk assessment should be reviewed once further relevant information becomes available.

7.1.3. Risk management

7.1.3.1. Risk evaluation

Since the risk estimate for ApSL associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

7.1.3.2. Option evaluation

There are conceivably a number of management options available for ApSL on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of ApSL;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of ApSL;
- **d.** Phytoplasma indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

As little is known about ApSL or its epidemiology, information required to consider that no phytosanitary measures are necessary, such as a narrow host range causing limited impacts or a method of dispersal restricted to grafting, is unavailable. Should suitable information on this hazard or the disease it causes become available, it may be possible to conclude that no phytosanitary measures are required.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Phytoplasma indexing of mother plants

As with all phytoplasma diseases, plants can be tested for ApSL using nested-PCR and universal phytoplasma primers (see section 4.3.3 for further details). Phytoplasma indexing should be considered an effective phytosanitary measure against ApSL.

Inspection of mother plants

Relying on the detection of ApSL infection without targeted testing would offer little protection as this organism can remain latent in *Malus* hosts. Mother plant inspections alone should therefore not be considered an effective phytosanitary measure against ApSL.

7.1.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Jomantiene, R; Davis, R E (2005) Apple sessile leaf: a new disease associated with a 'Candidatus Phytoplasma asteris' subgroup 16SrI-B phytoplasma in Lithuania. *Plant Pathology* 54(2): 237.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

7.2. *Candidatus* Phytoplasma *mali* (AP, AT)

7.2.1. Hazard identification

7.2.1.1. Aetiologic agent

Candidatus Phytoplasma *mali* (Seemüller & Schneider, 2004) or Apple Proliferation (AP or AT), Order: Acholeplasmatales, Family: Acholeplasmataceae (CPC 2007)

7.2.1.2. New Zealand status

AP is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

7.2.1.3. Biology and epidemiology

The distribution of the phytoplasma within the infected tree is restricted to the functional phloem elements, with colonization of aboveground parts following a seasonal pattern. The phytoplasma disappears in the above ground parts during winter, when the complete inactivation of sieve tubes in aerial parts of pome fruit trees occurs. During this period the phytoplasma still survives in the roots, and in spring begins to re-colonize the stem and shoots after the development of a new phloem circle. The pathogen can then be acquired by sap-sucking insects, such as leafhoppers or planthoppers, within which it can multiply, circulate to the salivary glands, and be expelled during feeding probes to infect other plants. Once a vector is infected, it retains the ability to transmit the phytoplasma for the duration of its life span, and over-wintering adult psyllid vectors have been shown to carry the phytoplasma into the next spring (CPC 2007).

Temperature seems to have a significant impact on disease expression and therefore impact. An AP survey conducted in Germany showed that the phytoplasma was widely distributed outside of the area in southwest Germany where the disease is of greatest economic importance. In the southwest region it seems that the warmer temperatures enhance the growth of the phytoplasma, leading to high populations in the treetops and more obvious symptoms. In the warmer regions of southern Europe, such as in the Emilia-Romagna region of Italy, temperatures may be too high for good symptom development, whereas in the more northerly areas of Europe the temperatures may be too cool for good symptom development. This suggestion corresponds at least in part with results of an earlier study that found symptoms of AP developed at temperatures of 21-24°C, but not between 29 and 32°C (CPC 2007).

Symptoms

All symptoms may not develop repeatedly on the same branch; they may appear at once or successively over the whole tree or various parts. The leaves of infected plants roll downward and become brittle, are finely and irregularly serrated, are smaller than normal and turn red in autumn in contrast to the yellow coloration of healthy plants. The summer leaves are often chlorotic and defoliation may occur. A rosette of terminal leaves sometimes develops late in the season in place of normal dormant buds. Stipules are abnormally enlarged while petioles are rather short; this is an important symptom in nursery surveys (CPC 2007).

Shoots develop prematurely from axillary buds and give rise of secondary shoots forming witches' broom. The angle between the secondary shoots and the main shoot is abnormally narrow. Leaf rosette may appear on the shoot ends or the shoot tips may die back; this is also an important symptom in nursery surveys (CPC 2007).

In some cases, flowers show numerous petals and the peduncles are abnormally long. They fail to set and may stay on the tree for a long period. Fruits are few, small, incompletely coloured, and poorly flavoured (WSU 2003). Symptoms are unevenly distributed on the whole plant, often seemingly healthy branches are found with normal fruits. Affected trees are less vigorous, but rarely die. Sometimes after a shock phase, trees can produce normally, especially if adequately fertilized. The fibrous root system of infected trees forms compact felt-like masses of short roots so that larger ones are unable to develop. Root weight is reduced by 20-40%. The trunk circumference and crown diameter are reduced compared with healthy trees (CPC 2007).

Epidemiology

In the field, the disease seems to spread naturally by root fusion (Ciccotti *et al*. 2008) and by insect vectors (CPC 2007). In terms of the vectors, AP was experimentally transmitted from apple to apple and to *Catharanthus roseus* by the leafhopper vector *Philaenus spumarius*, from apple to *C. roseus* by *Aphrophora alni* and *Lepyronia coleoptrata*; and from infected celery plants to apple seedlings by *Arhianus interstitialis*. These experiments showed that nymphs can acquire the pathogen and transmit it in the adult stage. Adults were found to maintain the ability to transmit the phytoplasma up to the end of their life. The incubation period in apple lasts 1-2 years (CPC 2007).

More recently, the leafhopper *Fieberiella florii* was considered as a putative vector of apple proliferation phytoplasma. AP-DNA was revealed in the total DNA extracted from *F. florii* trapped in orchards with proliferation-diseased trees. Also, it has recently been demonstrated that the psyllids *Cacopsylla costalis*, *C. mali* and *C. melanoneura* are vectors, and psyllids seem to be the most important vectors for AP (CPC 2007, NAPPO PAS. 2006, Tedeschi & Alama 2004).

Arhianus interstitialis, *Aphrophora alni*, *Cacopsylla costalis*, *Cacopsylla mali*, *Cacopsylla melanoneura*, *Fieberiella florii*, and *Lepyronia coleoptrata* and are not known to be present in New Zealand (PPIN 2009, Larivière 2005), while *Philaenus spumarius* has been established in New Zealand since at least 1960 (PPIN 2009).

The disease is graft-transmissible, so long-distance spread could occur with the human movement of infected propagation materials, such as scionwood or rootstock materials. As the colonisation of aerial parts of *Malus* trees shows seasonal variations during the year, transmission rates of scionwood can vary from 0% to 30% depending on the season of collection (Pedrazzoli *et al*. 2008). Pedrazzoli *et al*. (2008) concluded that spring was the season when scionwood was least likely to be infected (0%-0.08%). The vegetatively propagated rootstocks are especially hazardous as they are generally symptomless. There is no seed or pollen transmission (CPC 2007). The pattern of occurrence of apple proliferation phytoplasma in European orchards suggests that the pathogen is harboured in the native weed population, from which it moves into the orchards (Grove *et al*. 2003).

Hosts

Malus domestica cultivars are the main hosts, and most cultivars are susceptible. Apple cultivars known to be affected by AP phytoplasma include 'Belle de Booskop', 'Gravestein', 'Golden Delicious', 'Winter Banana', 'Florina', 'Prima', 'Priscilla', 'Idared', 'McIntosh', 'Starking', 'Starkrimson', 'Roja de Benejama', 'Antonokova', 'Cortland', 'Spartan', 'Yellow transparent', and 'Wealthy'. In northern Italy serious epidemics have been reported to occur on the cultivars 'Golden Delicious', 'Florina', 'Canadian Renette' and 'Granny Smith', grafted on different rootstocks (CPC 2007).

The recorded natural host range includes *Malus domestica* (apple), *Catharanthus roseus* (Pink periwinkle), *Convolvulus arvensis* (bindweed), *Corylus avellana* (hazel), *Cynodon dactylon* (Bermuda grass), *Dahlia cultorum* (oriental lily), *Magnolia* sp. (magnolia), *Prunus avium* (cherry), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Prunus salicina* (Japanese plum), *Pyrus communis* (European pear), *Rosa* (rose) and *Vitis vinifera* (grapevine) (CPC 2007, Kaminska and Sliwa 2007a & b, Mehle *et al*. 2006).

Geographical distribution

AP has been recorded in Europe (Albania, Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Moldova, Netherlands, Norway, Poland, Romania, Southern Russia, Serbia & Montenegro, Slovakia, Slovenia, Spain, Switzerland, Ukraine), and Asia (Turkey). AP has not been detected in the USA (CPC 2007).

Further spread or propagation of the disease in infected budwood or plant material could lead to considerable yield losses throughout the European and Mediterranean apple cultivation areas.

7.2.1.4. Hazard identification conclusion

The accepted absence of AP in New Zealand, the ability of this phytoplasma to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that AP phytoplasma should be considered a potential hazard requiring further assessment.

7.2.2. Risk assessment

7.2.2.1. Entry assessment

There is little available information on the prevalence of this phytoplasma within infected *Malus* populations. The likelihood of the association of AP with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. Transmission rates of AP in scionwood can vary from 0% to 30% depending on the season of collection (Pedrazzoli *et al*. 2008). As with any phytoplasma, the likelihood of survival of long-distance transport in infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of AP into New Zealand with *Malus* nursery stock from infected populations is low to moderate and therefore non-negligible.

7.2.2.2. Assessment of exposure and establishment

Should AP be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

7.2.2.3. Consequence assessment

Spread

If the phytoplasma established in New Zealand, it could spread rapidly as it can be transmitted over short distances by an established or local leafhopper or psyllid (e.g. *Philaenus spumarius*) and long distance by human activities such as movement of infected sionwoods and rootstock. Hosts of AP such as *Malus domestica* (apple), *Convolvulus arvensis* (bindweed), *Corylus avellana* (hazel), *Cynodon dactylon* (Bermuda grass), *Prunus* sp., *Pyrus communis* (European pear), *Rosa* sp. and *Vitis vinifera* (grapevine), are readily available throughout New Zealand. The likelihood of spread after establishment is therefore considered high.

Economic consequences

AP is considered one of the most important phytoplasma diseases of apple, particularly in the northern areas of southern Europe, where temperatures are the most conducive to symptom expression. Outside of this region, where cooler or warmer growing conditions occur, the disease appears to be of less importance (CPC 2007). Most parts of New Zealand are within the favourable temperature range (21-24°C) for symptom development.

AP is reported to affect almost all apple varieties, causing reductions in (CPC 2007, Grove *et al*. 2003, Németh 1986):

(i) fruit size by up to 50%;

(ii) fruit weight by 63-74%;

(iii) fruit quality, through the reduction of sugar and acid content; and

(iv) tree vigour.

AP also increases susceptibility of infected trees to other plant pathogens, such as powdery mildew (*Podosphaera leucotricha*), or the silver leaf fungus (*Chondrostereum purpureum*). Most significant losses (up to 80%) are incurred during the acute phase of the disease (i.e. shock phase), although a considerable percentage of fruit remains undersized even after this period. In some cases, AP can also lead to premature death of infected trees (CPC 2007, Grove *et al*. 2003, Németh 1986).

Given the significance of this phytoplasma it is considered that should AP be introduced into New Zealand there is a moderate likelihood that the economic consequences could be high.

Environmental consequences

The pattern of occurrence of AP phytoplasma in European orchards suggests that the pathogen is harboured in the native weed population, from which it moves into the orchards. Hosts of such include *Convolvulus arvensis* (bindweed), which is localised in New Zealand, and *Cynodon dactylon* (Bermuda grass) which is widespread in New Zealand. While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by AP, namely leaf necrosis and reduce tree vigour, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by AP lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of AP in New Zealand should therefore be considered to have a low likelihood of being low.

Human Health consequences

This organism is not known to be of any significance to human health.

7.2.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that AP has a moderate likelihood of causing high economic consequences and a low likelihood of causing low environmental consequences to New Zealand.

7.2.2.5. Risk estimation

The likelihood estimate is low to moderate that AP would be associated with *Malus* nursery stock on entry into New Zealand, high that any AP that does enter would successfully establish in New Zealand, moderate that the establishment would result in high economic consequences, and low that the establishment would result in low environmental consequences to New Zealand. As a result the risk estimate for AP associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

7.2.2.6. Assessment of uncertainty

There is uncertainty around the biology, distribution and epidemiology of this phytoplasma. As such this risk assessment should be reviewed once further relevant information becomes available.

7.2.3. Risk management

7.2.3.1. Risk evaluation

Since the risk estimate for AP associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

7.2.3.2. Option evaluation

There are conceivably a number of management options available for AP on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of AP;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of AP;
- **c.** Phytoplasma indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

AP is routinely detected by visual observation and field-testing on *Malus domestica* cultivar 'Golden Delicious' (side interstock grafting) using five repetitions for 2 years. Application of surveys incorporating methods such as these could be used to verify a PFA. A PFA declaration supported by an appropriate survey should be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

Given the ability of AP phytoplasma to be carried by vector organisms over a number of seasons after disease eradication (overwintering adult psyllid vectors have been shown to still carry the phytoplasma the next spring (Tedeschi & Alama 2004)), care should be taken when considering exclusion conditions to ensure the PFPP status remains appropriate. While at this time this option may not be considered feasible, should an appropriate method to ensure exclusion be identified for AP a PFPP declaration could be considered an effective phytosanitary measure.

Phytoplasma indexing of mother plants

The most widely accepted detection method for apple proliferation phytoplasma has been woody indexing in the field. Bark patches from roots of the test plant are budded on to 'Golden Delicious' and the tree observed for 2 years for the appearance of witches'-broom and the enlarged stipules (Grove *et al*. 2003). If the very sensitive indicator *Malus* x *dawsoniana* is grafted directly in June on the scion, it develops a leaf reddening during the following autumn and a bark splitting and scaling during the next spring. The use of DAPI reagent (1,6 diamidino 2-phenylindole) can help to detect the fluorescence of phytoplasmas in the sieve tubes of phloem tissue under the bark of infected apple trees (CPC 2007).

However, the long observation period and concern about reliable transmission of the pathogen encouraged the development of alternative detection methods. Detection by PCR is becoming widely accepted and the techniques are becoming increasingly refined to improve the reliability of molecular methods. PCR is now the preferred test method (Grove *et al*. 2003). As with all phytoplasma diseases, plants can be tested for AP using nested-PCR and the universal phytoplasma primers (see section 4.3.3 for further details). At least five samples per plant should be randomly collected in order to avoid false negative results due to the low titre and erratic distribution of these pathogens in the phloem of the plant. Samples from leaves, petioles, shoots and canes should be collected in the last month of summer (August in Europe) (Pedrazzoli *et al*. 2008, CPC 2007).

There is currently no information on the reliability of the graft-transfer of AP infected plants on to susceptible indicator plants, or the sensitivity and specificity of the diagnostic tests. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, graft indexing should be considered an effective phytosanitary measure against AP. PCR testing should also be considered an effective phytosanitary measure against AP.

Inspection of mother plants

As AP is considered latent in many commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of AP (e.g. *Malus* x *dawsoniana* or *Malus domestica* cultivar 'Golden Delicious'). Assuming symptomatic mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against AP.

7.2.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Ciccotti AM, Bianchedi PL, Bragagna P, Deromedi M, Filippi M, Forno F, Mattedi L (2008) Natural and experimental transmission of *Candidatus* Phytoplasma mali by root bridges. Acta Horticulturae. *International Society for Horticultural Science* (ISHS), Leuven, Belgium: 781, 459-464.

CPC (2005) *Crop Protection Compendium on Internet.* CAB International, Wallingford, UK; http://www.cabi.org/compendia/CPC/

EPPO (1992) Datasheets on quarantine pests: Apple proliferation. http://www.eppo.org/QUARANTINE/bacteria/Apple_proliferation/PHYP14_ds.pdf

Grove, G G; Eastwell, K C; Jones, A L; Sutton, T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (eds) *Apples: Botany, Production and Uses.* CAB International; 459-579.

Kaminska, M; Sliwa, H (2007a) Mixed infection of dahlia plants in Poland with apple proliferation and aster yellows phytoplasmas. British Society of Plant Pathology, New disease Reports 08/03/07; http://www.bspp.org.uk/ndr/july2007/2007-29.asp

Kaminska, M; Sliwa, H (2007b) First report of '*Candidatus* Phytoplasma mali' in oriental lilies and its association with leaf scorch in Poland. British Society of Plant Pathology, New disease Reports 21/06/07; http://www.bspp.org.uk/ndr/july2007/2007-52.asp

Larivière, M-C (Ed.) (2005) Checklist of New Zealand Hemiptera (excluding Sternorrhyncha), V 3; www.landcareresearch.co.nz/research/biosystematics/invertebrates/hemwsite/nzhemlist/

Mehle, N; Brzin, J; Boben, J; Hren, M; Frank, J; Petrovic, N; Gruden, K; Dreo, T; Zezlina, I; Seljak G; Ravnikar. M (2006) First report of '*Candidatus* Phytoplasma mali' in stone fruits (*Prunus* spp.). British Society of Plant Pathology, New Disease Reports; Available at: http://www.bspp.org.uk/ndr/jan2007/2006-90.asp

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

NAPPO PAS (2006) *Fieberiella florii*, a North American Leafhopper Confirmed as a Vector for Apple Proliferation Phytoplasma. North American Plant Protection Organization. Phytosanitary Alert System; http://www.pestalert.org/viewNewsAlert.cfm?naid=10

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pedrazzoli F, Filippi M, Deromedi M, Bragagna P, Battocletti I, Bianchedi PL, Ciccotti AM, Stoppa G (2008) Apple proliferation transmission by grafting in different periods of the year. Acta Horticulturae. *International Society for Horticultural Science* (ISHS), Leuven, Belgium: 781, 489-493.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Pest Information Network. MAF database.

Seemüller E, Schneider B (2004) '*Candidatus Phytoplasma mali*', '*Candidatus* Phytoplasma *pyri*' and '*Candidatus* Phytoplasma *prunorum*', the causal agents of apple proliferation, pear decline and European stone fruit yellows, respectively. *International Journal of Systematic and Evolutionary Microbiology* 54(4): 1217-1266.

Tedeschi R, Alama A (2004) Transmission of apple proliferation phytoplasma by *Cacopsylla melanoneura* (Homoptera: Psyllidae). Journal of Economic Entomology, 97(1):8-13.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

7.3. *Candidatus* Phytoplasma *pyri* (PD)

7.3.1. Hazard identification

7.3.1.1. Aetiologic agent

Candidatus Phytoplasma *pyri* (Seemüller & Schneider, 2004) or Pear decline (PD) (CPC 2007), Class: Mollicutes, Order: Acholeplasmatales, Family: Acholeplasmataceae (CPC 2007)

7.3.1.2. New Zealand status

PD is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

7.3.1.3. Biology and epidemiology

The major host of PD is *Pyrus.* Pear trees on rootstocks of *P. pyrifolia* and *P. ussuriensis* are prone to tree collapse. The disease has also been observed on quinces and occasionally on trees grafted onto rootstocks of this species. The susceptible scion/rootstocks are not commonly grown (Smith *et al*. 1997). There is no report on the incident of *Malus* being infected by PD. The association of PD with *Malus* budwood is therefore questionable however CPC (2007) lists *Malus domestica* as a host. The epidemiology of the disease is still poorly understood (CPC 2007).

7.3.1.4. Hazard identification conclusion

Given the lack of epidemiological information available on PD, the questionable association with *Malus*, and the only available phytosanitary measures for this phytoplasma being the same as the other phytoplasma organisms (see Chapter 5), the recommendation of this risk analysis is that PD should not be considered a potential hazard on *Malus* nursery stock.

7.3.1.5. Assessment of uncertainty

There is significant uncertainty around the biology, distribution and epidemiology of this phytoplasma in relation to *Malus*. As such this risk assessment should be reviewed once further relevant information becomes available on the status of *Malus* as a host.

7.3.2. References

CPC (2005) *Crop Protection Compendium on Internet.* CAB INTERNATIONAL, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

Seemüller E, Schneider B (2004) '*Candidatus* Phytoplasma *mali*', '*Candidatus* Phytoplasma *pyri*' and '*Candidatus* Phytoplasma *prunorum*', the causal agents of apple proliferation, pear decline and European stone fruit yellows, respectively. *International Journal of Systematic and Evolutionary Microbiology* 54(4): 1217-1266.

Smith, I M; McNamara, D G; Scott, P R; Holderness, M; Burger B (eds) (1997) Quarantine Pests for Europe. CABI and EPPO pub (2nd edition); pp 1425.

8. Risk analyses - Diseases of unknown aetiology

8.1. Apple blister bark agent

8.1.1. Hazard identification

8.1.1.1. Aetiologic agent

Apple Blister Bark is a disease of unknown aetiology.

8.1.1.2. New Zealand status

Apple Blister Bark agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.1.1.3. Biology and epidemiology

Symptoms of Apple Blister Bark occur worldwide on the cultivar 'Delicious' and its sports[6], particularly spur-type sports (Jones & Aldwinckle 1990). Apple Blister Bark is characterized by areas of the bark taking on the appearance of orange tissue paper. Orange to tan areas begin to appear on the bark of 2-year-old wood during autumn, and new areas appear on older wood affected in previous years. The bark tissue underneath these areas is reddish, spongy, and watery at first, becoming hard and dry later. As the underlying tissue becomes desiccated the bark cracks and peels. By late autumn the discoloured areas appear blistered. Affected areas on the bark may occur in bands or ring-like patterns on large limbs. Occasionally a dieback occurs when affected areas coalesce. Small branches beyond the blistered areas often exhibit internal bark necrosis. The affected branches appear more sensitive to low-temperature injury and may be killed in years with unusually low winter temperatures. Several mineral deficiencies can mimic infection by Apple Blister Bark, so proper diagnosis is important (Jones & Aldwinckle 1990, Grove *et al*. 2003).

<u>Apple blister bark 1:</u> No leaf symptoms have been documented. Initial symptoms appear as dry, paper thin, orange areas, which slough off. The exposed underlying tissue is prone to drying, cracking, and peeling. Affected areas have greater susceptibility to winter injury. Internal bark necrosis and twig dieback occurs on limbs that are 1-year old or older. Fruits develop no diagnostic symptoms in most apple cultivars (WSU 2003).

<u>Apple blister bark 2:</u> No leaf symptoms have been observed. Initial symptoms appear identical to apple blister bark 1 except internal bark necrosis does not occur. Fruits develop no diagnostic symptoms in most apple cultivars (WSU 2003).

<u>Apple blister bark 3:</u> No leaf symptoms have been observed. Initial symptoms appear identical to apple blister bark 1 except internal bark necrosis does not occur. Fruits develop no diagnostic symptoms in most apple cultivars (WSU 2003).

Apple Blister Bark is graft-transmissible (Grove *et al*. 2003, WSU 2003) and is recorded as being present in the USA but not Canada or Mexico (NAPPO 2004).

8.1.1.4. Hazard identification conclusion

The accepted absence of Apple Blister Bark in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease

6 Apple cultivar 'Delicious' sports include 'Red Delicious' varieties (All about apples 2009).

symptoms in New Zealand all suggest that the Apple Blister Bark agent should be considered a potential hazard requiring further assessment.

8.1.2. Risk assessment

8.1.2.1. Entry assessment

Symptoms of Apple Blister Bark occur worldwide on the *Malus* cultivar 'Delicious' and its sports, particularly spur-type sports. However there is little available information on the prevalence of Apple Blister Bark within infected *Malus* populations. The likelihood of the association of Apple Blister Bark with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Blister Bark agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Blister Bark agent into New Zealand with *Malus* nursery stock from infected populations is low to moderate and therefore non-negligible.

8.1.2.2. Assessment of exposure and establishment

Should the Apple Blister Bark agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.1.2.3. Consequence assessment

Spread

The hosts of Apple Blister Bark agent (*Malus*) are readily available throughout New Zealand. The symptoms occur worldwide, which suggests climate may not be a constraint factor. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Blister Bark after establishment is therefore considered low.

Economic consequences

Symptoms appear mostly on bark, with fruit developing no diagnostic symptoms in most apple cultivars. No report was found on the effect on fruit quality or yield loss. There are unlikely to be any market access issues resulting from Apple Blister Bark disease in an apple orchard. The potential economic impact of Apple Blister Bark on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by the Apple Blister Bark agent, namely localised bark necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Identifying any alternative hosts would most likely first require identifying the causal agent. Naturalised introduced host species of the fruit trees in the urban environment might be affected by Apple Blister Bark agent lowering tree vitality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of Apple Blister Bark agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Blister Bark agent is not known to be of any significance to human health.

8.1.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Blister Bark has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.1.2.5. Risk estimation

The likelihood estimate is low to moderate that the Apple Blister Bark agent would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Blister Bark agent that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Blister Bark associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.1.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Blister Bark. As such this risk assessment should be reviewed once further relevant information becomes available.

8.1.3. Risk management

8.1.3.1. Risk evaluation

Since the risk estimate for Apple Blister Bark agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.1.3.2. Option evaluation

There are conceivably a number of management options available for Apple Blister Bark on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Blister Bark;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Blister Bark;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on two-year-old wood, woody indexing on the *Malus* cultivar ‘Delicious’ or ‘Red Delicious’ should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical inoculation of Apple Blister Bark infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Blister Bark.

Inspection of mother plants

As disease symptoms are expressed on two-year-old *Malus* wood, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Blister Bark. Inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Narrow Leaf (e.g. the *Malus* cultivar ‘Delicious’ or ‘Red Delicious’). Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Blister Bark.

8.1.4. References

All About Apples (2009) All about apples. Web based information available at http://www.allaboutapples.com/index.htm

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (Pyrus) Budwood. Biosecurity Australia; 68pp.

Grove, G G; Eastwell, K C; Jones, A L; Sutton, T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (ed) Apples: Botany, Production and Uses. CAB International; 459-579.

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.2. Apple brown ringspot agent

8.2.1. Hazard identification

8.2.1.1. Aetiologic agent

Apple Brown Ringspot is a disease of unknown aetiology.

8.2.1.2. New Zealand status

Apple Brown Ringspot agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009).

8.2.1.3. Biology and epidemiology

Based on the symptoms, the Apple Brown Ringspot is considered identical with or related to Apple Russet Ring, Apple Green Mottle (Apple Green Dimple and Ring Blotch agent) or Apple Ringspot agents (Németh 1986). Symptoms described for Apple Green Mottle on *Malus* cultivars include:

- Fruits of naturally infected 'Duchess' trees are covered by green spots;
- Fruits of 'Golden Delicious' and of graft-inoculated 'Lord Lambourne' develop russet rings and spots.

Unlike Apple Russet Ring, leaves and bark on Apple Brown Ringspot affected trees do not develop diagnostic symptoms (WSU 2003). No reliable indicator plant has yet been found for demonstrating the presence of a virus or any other aetiological agent (Németh 1986). Apple Brown Ringspot is reported though rarely found in North America (WSU 2003) and occurs only sporadically (Németh 1986).

8.2.1.4. Hazard identification conclusion

The accepted absence of Apple Brown Ringspot in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Brown Ringspot agent should be considered a potential hazard requiring further assessment.

8.2.2. Risk assessment

8.2.2.1. Entry assessment

The likelihood of the association of Apple Brown Ringspot agent with trees from which any *Malus* budwood is taken for export to New Zealand is likely to be low due to the rare and sporadic occurrence of the disease in infected populations. The likelihood of survival of the Apple Brown Ringspot agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is considered that the likelihood of entry of the Apple Brown Ringspot agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.2.2.2. Assessment of exposure and establishment

Should the Apple Brown Ringspot agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.2.2.3. Consequence assessment

Spread

There is no specific information on the transmission of Apple Brown Ringspot agent. At a minimum it is likely that plant parts such as fruit, flowers, leaves, roots and stems are liable to carry the agent in trade and transport. Apple Brown Ringspot disease is reported though rarely found (WSU 2003) and occurs only sporadically (Németh 1986). It is therefore considered that the likelihood of spread is low.

Economic consequences

Because it occurs only sporadically, Németh (1986) consider its economic importance is slight. Potential trade restrictions may present the largest economic consequence. The potential economic impact of Apple Brown Ringspot agent on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Brown Ringspot agent, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Brown Ringspot agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of Apple Brown Ringspot agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Brown Ringspot agent is not known to be of any significance to human health.

8.2.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Brown Ringspot has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.2.2.5. Risk estimation

The likelihood estimate is low that Apple Brown Ringspot would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Brown Ringspot that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Brown Ringspot associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

Given that level of assessed risk from Apple Brown Ringspot is low at every point in the assessment, and there is no evidence to suggest this disease has had significant impacts at any time, the conclusion that the risk is non-negligible should be qualified by the high level of uncertainty.

8.2.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Brown Ringspot. As such this risk assessment should be reviewed once further relevant information becomes available.

8.2.3. Risk management

8.2.3.1. Risk evaluation

Since the risk estimate for Apple Brown Ringspot agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.2.3.2. Option evaluation

There are conceivably a number of management options available for Apple Brown Ringspot on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Brown Ringspot;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Brown Ringspot;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

The level of assessed risk from Apple Brown Ringspot is low at every point in the assessment, and there is no evidence to suggest this disease has had significant impacts at any time. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept this level of risk, given the benefits they may potential receive from the imports.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of Apple Brown Ringspot is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on two-year-old wood, woody indexing on the *Malus* cultivar 'Golden Delicious' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical inoculation of Apple Brown Ringspot infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Brown Ringspot.

Inspection of mother plants

As disease symptoms are expressed on two-year-old *Malus* wood, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Brown Ringspot. Inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Narrow Leaf (e.g. the *Malus* cultivar 'Golden Delicious'). Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Brown Ringspot.

8.2.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Németh, M V (1986) *Virus, mycoplasma and rickettsia diseases of fruit trees.* Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.3. Apple bumpy fruit agent

8.3.1. Hazard identification

8.3.1.1. Aetiologic agent

Apple Bumpy Fruit (India or Ben Davis) is a disease of unknown aetiology.

8.3.1.2. New Zealand status

Apple Bumpy Fruit agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.3.1.3. Biology and epidemiology

According to Behl *et al.* (1998), routine inspections in some apple orchards in Himachal Pradesh (H.P.) revealed a serious disease in *Malus* cultivar 'Golden Delicious' trees. The disease was diagnosed as 'bumpy fruit' based on symptoms including the bumps observed on fruit of infected trees. Perceptible symptoms of Apple Bumpy Fruit were confined only to the fruits while the trees usually lacked vigour, bore scarce foliage and had few fruits on each branch. Initially, the fruit surface developed depressions, at times including a 'false-sting', which became prominent with bumps upon fruit maturity even though the fruit neither gained much size nor changed in colour as compared to the fruit on healthy trees. Infected trees also had some fruits which, at maturity, showed hard wart-like swellings with or without wedges or cracking of varying patterns. The fruits grew slowly in the latter part of the season and fruit quality (sweetness and storage life) was also affected (Behl *et al.* 1998).

According to Behl *et al.* (1998), the disease incidence was reported as low at present (0.1 - 1.6%) yet there were suggestions that it may be on the increase. The transmission appears mainly to be due to mechanical injury and grafting. A common symptom observed for both 'dapple apple' and 'bumpy fruit' diseases is the initial appearance of dark green spots on young fruits. There may be differences between symptoms on different cultivars yet occurrence of strains of the pathogen cannot be ruled out (WSU 2003).

It is considered that the causal agent may be related to apple green crinkle virus, but this has not yet been proved. It is also questioned whether the causal agent might be related to Apple green crinkle or Apple scar-skin viroid (WSU 2003). Behl *et al.* (1998) reported, "*A variant of apple scar skin viroid was found to be associated with bumpy fruit disease of apple in India based on the RT-PCR assays done with diseases samples at Beltsville.*" These conflicting accounts suggest that further work may link Apple Bumpy Fruit to a known viral or viroid disease agent of apple.

While the only formally published presence of Apple Bumpy Fruit agent may be India, this disease may occur in other regions as evident by the alternative description provided by WSU (2003). The EPPO testing standard for apple diseases uses apple cultivar 'Lord Lambourne' as the indicator plant and describes yellow leaf spots and deformation of the leaf blade as the diagnostic symptoms (EPPO 2009).

8.3.1.4. Hazard identification conclusion

The accepted absence of Apple Bumpy Fruit in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Bumpy Fruit agent should be considered a potential hazard requiring further assessment.

8.3.2. Risk assessment

8.3.2.1. Entry assessment

There is little available information on the prevalence of this disease within infected *Malus* populations aside from the comment that “incidence is low at present (0.1 - 1.6%) yet some growers suggested it to be on the increase” in India (Behl *et al.* 1998, WSU 2003). The likelihood of the association of Apple Bumpy Fruit with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Bumpy Fruit agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Bumpy Fruit agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.3.2.2. Assessment of exposure and establishment

Should the Apple Bumpy Fruit agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.3.2.3. Consequence assessment

Spread

The hosts of Apple Bumpy Fruit agent (*Malus domestica* cultivars) are readily available throughout New Zealand. The disease is though to be mechanically and graft-transmitted, thus it can be spread by human activities through budding, grafting and pruning. No vector is known to transmit the disease. The likelihood of the spread of Apple Bumpy Fruit after establishment is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit, with the tree developing some symptoms. Fruit quality and yield would be significantly affected in infected trees. Potentially significant market access may result from Apple Bumpy Fruit disease development in an apple orchard, although the low level of persistence would minimise this impact. The potential economic impact of apple blister bark on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Bumpy Fruit agent, namely localised fruit deformation and lower tree vigour, while being of potential concern in commercial production, are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Bumpy Fruit agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Bumpy Fruit agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Bumpy Fruit agent is not known to be of any significance to human health.

8.3.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Bumpy Fruit bark has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

8.3.2.5. Risk estimation

The likelihood estimate is low to moderate that Apple Bumpy Fruit would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Bumpy Fruit that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Bumpy Fruit associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.3.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Bumpy Fruit. As such this risk assessment should be reviewed once further relevant information becomes available.

8.3.3. Risk management

8.3.3.1. Risk evaluation

Since the risk estimate for Apple Bumpy Fruit agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.3.3.2. Option evaluation

There are conceivably a number of management options available for Apple Bumpy Fruit on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Bumpy Fruit;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Bumpy Fruit;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

In the case of Apple Bumpy Fruit it may also be reasonable to assume that the causal agent is a known viral or viroid disease agent of apple that, if considered a hazard, will be managed by phytosanitary measures provided in other schedules within this risk analysis.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on two-year-old wood, woody indexing on the *Malus* cultivar ‘Golden Delicious’ or ‘Lord Lambourne’ should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical inoculation of Apple Blister Bark infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Bumpy Fruit.

Inspection of mother plants

As disease symptoms are expressed on two-year-old *Malus* wood, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Bumpy Fruit. Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Bumpy Fruit.

8.3.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Behl M K, Khurana S, Parakh M P (1998) DB Bumpy fruit and other viroid and viroid-like diseases of apple in HP, India. Acta Horticulturae. 472, 627-630.

EPPO (2009) Pathogen-tested material of *Malus*, *Pyrus* and *Cydonia*. EPPO Standards Certification Schemes. *European and Mediterranean Plant Protection Organization*: 15pp. Available online at http://archives.eppo.org/EPPOStandards/certification.htm

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.4. Apple bunchy top agent

8.4.1. Hazard identification

8.4.1.1. Aetiologic agent

Apple Bunchy Top is a disease of unknown aetiology (WSU 2003).

8.4.1.2. New Zealand status

Apple Bunchy Top agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.4.1.3. Biology and epidemiology

Apple Bunchy Top disease has been reported but is rarely found (WSU 2003). Apple Bunchy Top is recorded as being absent from USA, Canada and Mexico (NAPPO 2004) and Australia (BA 2002). Gupta V K (1990) reports that "bunchy top" is know to occur in India and is controlled by indexing-based certification schemes implemented for control of viral diseases of apple. There is no further information provided on the biology or epidemiology of this disease.

8.4.1.4. Hazard identification conclusion

Given the absence of any substantial understanding of the biology or epidemiology of Apple Bunchy Top disease, and its reported rarity, it is recommended that this disease of unknown aetiology not be considered a potential hazard in this risk analysis.

8.4.1.5. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Bunchy Top. As such this risk assessment should be reviewed once further relevant information becomes available.

8.4.2. Reference

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Gupta V K (1990) An integrated approach to managing apple diseases under Indian conditions. *Acta Horticulturae* 279: pgs 619-625.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.5. Apple dead spur agent

8.5.1. Hazard identification

8.5.1.1. Aetiologic agent

Apple Dead Spur is a disease of unknown aetiology.

8.5.1.2. New Zealand status

Apple Dead Spur agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.5.1.3. Biology and epidemiology

The primary symptom on spur-type apple trees is the death of the fruiting spurs in the centre of the trees. While live spurs remain near the terminal ends of shoots of an affected tree, a gradient of healthy, weak, dying, and dead spurs are found between the terminal ends and the centre of the tree. As much as 70% of the spurs on a tree may die. On non-spur-type apple trees, many of the lateral buds fail to produce vegetative growth which also results in an open tree (Jones & Aldwinckle 1990, WSU 2003).

The first symptom of dead spur is the appearance of weak spurs, usually during the first year after fruiting. Leaf abscission from affected spurs is delayed in the autumn. The following year, some weak spurs fail to break dormancy, although they remain alive. A few weeks later, those buds die. Buds on other affected spurs grow, but the leaves are small, and the spurs often die by midsummer. The phloem of affected spurs appears as a pink halo in fresh cross sections. Fruits do not develop diagnostic symptoms (Jones & Aldwinckle 1990, WSU 2003).

Dead spur is graft and soil transmitted (Jones & Aldwinckle 1990, WSU 2003). There is no known vector for the Apple Dead Spur agent (Jones & Aldwinckle 1990). The transmission and disease characteristics suggest Apple Dead Spur is caused by a virus-like agent (Jones & Aldwinckle 1990).

Dead spur was first observed on *Malus* in the US in the late 1960s. It has since been observed in Oregon, Idaho, Georgia, and the Carolinas, in British Columbia, and in Poland. The disorder possibly grows wherever susceptible cultivars are grown (Jones & Aldwinckle 1990). *Malus* cultivars tested that expressed symptoms after graft inoculation include 'Red Winesap', 'Golden Delicious', and 'Granny Smith' (Jones & Aldwinckle 1990).

8.5.1.4. Hazard identification conclusion

The accepted absence of Apple Dead Spur in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Dead Spur agent should be considered a potential hazard requiring further assessment.

8.5.2. Risk assessment

8.5.2.1. Entry assessment

There is little available information on the prevalence of Apple Dead Spur within infected *Malus* populations. The likelihood of the association of Apple Dead Spur with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. Disease symptoms, especially weak, dying and dead spurs buds failing to produce vegetative growth, would make symptomatic material unsuitable for budwood production. However latent infections would not be screened out in this way. The likelihood of survival of the Apple Dead Spur agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Dead Spur agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.5.2.2. Assessment of exposure and establishment

Should the Apple Dead Spur agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.5.2.3. Consequence assessment

Spread

The host of Apple Dead Spur (apple) is readily available throughout New Zealand, and the climate in New Zealand is similar to that of the current distribution of this disease. The disease can be transmitted by grafting and soil, however, currently no vector is known. The likelihood of spread is considered low to moderate.

Economic consequences

As much as 70% of the spurs on a tree may die. On non-spur-type apple trees, many of the lateral buds fail to produce vegetative growth resulting in an open tree. Fruit does not develop diagnostic symptoms. These symptoms suggest the disease has the potential to have a significant effect on fruit production. As the disease currently has a limited distribution, other countries may require phytosanitary measures affecting market access. The potential economic impact of Apple Dead Spur on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena, Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Dead Spur agent, namely bud necrosis and subsequent tree decline, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Dead Spur agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Dead Spur agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Dead Spur agent is not known to be of any significance to human health.

8.5.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Dead Spur has a low likelihood of causing low to moderate economic consequences and low environmental consequences to New Zealand.

8.5.2.5. Risk estimation

The likelihood estimate is low to moderate that Apple Dead Spur would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Dead Spur that does enter would successfully establish in New Zealand, and low that the establishment would result in low to moderate economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Dead Spur associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

8.5.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Dead Spur. As such this risk assessment should be reviewed once further relevant information becomes available.

8.5.3. Risk management

8.5.3.1. Risk evaluation

Since the risk estimate for Apple Dead Spur agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.5.3.2. Option evaluation

There are conceivably a number of management options available for Apple Dead Spur on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Dead Spur;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Dead Spur;
- **c.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is largely unknown, inspection for symptom expression is the only feasible option available. As first symptom of dead spur is the appearance of weak spurs, usually during the first year after fruiting, woody indexing on the *Malus* cultivar

‘Red Winesap’, ‘Golden Delicious’ or ‘Granny Smith’ should be followed by inspections over a minimum of two growing seasons after fruiting, which include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Dead Spur infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Blister Bark.

Inspection of mother plants

As first symptom of dead spur is the appearance of weak spurs, usually during the first year after fruiting, inspections should occur over a minimum of two growing seasons after fruiting, which include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Dead Spur. Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Dead Spur.

8.5.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and *Xylella fastidiosa*. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.6. Apple decline agent

8.6.1. Hazard identification

8.6.1.1. Aetiologic agent

Apple Decline is a disease of unknown aetiology.

8.6.1.2. New Zealand status

Apple Decline agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

However, if Apple Decline is caused by Apple Stem Pitting Virus (ASPV) or Apple Stem Grooving Virus (ASGV), both of these viruses have been recorded in New Zealand.

8.6.1.3. Biology and epidemiology

Initially, one limb exhibits small rolled leaves and reduced terminal growth. Within a year, the rest of the tree exhibits these symptoms, and the originally affected limb dies back from the tip. By the third year, most of the tree has been affected by die back. It continues to decline until it dies, usually in 4-5 years. This disorder appears to originate at one point in the orchard and spreads in all directions. Roots appear normal except for the absence of small feeder roots. Fruits are small, later maturing, and usually unmarketable (Jones & Aldwinckle 1990).

WSU (2003) reports that an Apple Decline in crab apple cultivar 'Virginia Crab' (Apple Decline (Virginia Crab)) is caused by Apple Stem Grooving Virus (ASGV). This virus is latent in most commercial apple cultivars; however in declining 'Virginia Crab' trees, leaves appear chlorotic. The growth of infected 'Virginia Crab' trees is almost completely arrested; the bark becomes reddish-brown, and swelling and brown necrotic lines appear at or near the union (Nemeth 1986). Diseased trees bear small, deformed, premature fruit and trees die after 4 to 5 years (WSU 2003). Stem grooving caused by ASGV is not seen on current commercial apple cultivars, but appears on rootstocks with crab apple in their heritage (Grove et al 2003).

WSU 2003 also reports that Apple Decline on *Malus robusta* No. 5 has no known causal agent. In the combinations *M. robusta* No. 5 rootstock and infected scion, two syndrome types can be observed among affected trees:

- Pitting in the xylem wood near the base of the trunk; and
- Smallness and weakness in the plants.

In both, foliage is sparse and light green. On the trunk and limbs of *M. robusta*, severe bark scaling develops, and in the inner layers of the bark pockets of tissue become necrotic (WSU 2003). Parish (1989) and Jones & Aldwinckle (1990) report that a mycoplasma-like organism associated with the disease appears to spread to adjacent trees.

Apple Decline has been recorded in Washington, USA (Parish 1989).

8.6.1.4. Hazard identification conclusion

The accepted absence of Apple Decline in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Decline should be considered a potential hazard requiring further assessment.

8.6.2. Risk assessment

8.6.2.1. Entry assessment

There is little available information on the prevalence of Apple Decline within infected *Malus* populations. The likelihood of the association of Apple Decline with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of Apple Decline in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of Apple Decline into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.6.2.2. Assessment of exposure and establishment

Should Apple Decline be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.6.2.3. Consequence assessment

Spread

The hosts of Apple Decline (apple) are readily available throughout New Zealand. While no method of transmission has been identified, the disease has been found to spread through and between orchards suggesting grafting transmission and either soil (root) or insect vectoring. Given the low incidence of this disease in the infected population, the likelihood of the spread of Apple Decline should be considered low.

Economic consequences

Symptoms appear mostly on leaves and branches, but the causal agent may be latent on some cultivars. No report was found on the effect on fruit quality or yield loss within an infested population. There are unlikely to be any market access issues resulting from Apple Decline in an apple orchard, as the traded fruit are unlikely to be infected. The potential economic impact of Apple Decline on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Decline agent, namely localised bark necrosis and plant decline, while being of potential concern in commercial production, are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Decline agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Decline agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

Apple Decline is not known to be of any significance to human health.

8.6.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Decline has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.6.2.5. Risk estimation

The likelihood estimate is low that Apple Decline would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Decline that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Decline associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

8.6.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Decline. As such this risk assessment should be reviewed once further relevant information becomes available.

8.6.3. Risk management

8.6.3.1. Risk evaluation

Since the risk estimate for Apple Decline associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.6.3.2. Option evaluation

There are conceivably a number of management options available for Apple Decline on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Decline;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Decline;
- **c.** Inspection of mother plants.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Inspection of mother plants

As disease symptoms are expressed on two-year-old *Malus* wood, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Decline. Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Decline.

8.6.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Grove, G G; Eastwell, K C; Jones, A L; Sutton, T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (ed) Apples: Botany, Production and Uses. CAB International; 459-579.

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Parish, C L (1989) Apple decline: characterization, cause and cure. Acta Horticulturae (235): 93-97.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.7. Apple freckle scurf agent

8.7.1. Hazard identification

8.7.1.1. Aetiologic agent

Apple Freckle Scurf is a disease of unknown aetiology.

8.7.1.2. New Zealand status

Apple Freckle Scurf agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.7.1.3. Biology and epidemiology

There is little available information on the epidemiology or biology of Apple Freckle Scurf disease. WSU (2003) reports that on the bark of diseased trees, small, elevated freckles appear, under which thin necrotic tissue layers are formed. These small freckles crack open, allowing the bark to scab and peel. Fruit and leaves have not been found to develop diagnostic symptoms. Apple Freckle Scurf is reported though rarely found in North America (Cheney *et al.* 1970, WSU 2003).

Jones & Aldwinckle (1990) report that the symptoms of 'freckle scurf' first appear as above in 2- to 3-year-old limbs of the apple cultivar 'Stayman Winesap'. On wood 4 years and older the bumps erupt rather than collapse, to form rough, scruffy bark which peels with age. Apple Freckle Scurf is graft transmissible and therefore spread by infected budwood, however is not prevalent in affected orchards in North America (Jones & Aldwinckle 1990). Cheney *et al.* (1970) reported that 'freckle scurf' is graft transmissible, and symptoms on 'Winesap' apple at first resemble those of pustule canker but are very superficial, the small black bumps appearing to erupt rather than collapse, forming rough, scurfy bark. A 3-4 year incubation period was required before symptoms were detected (Cheney *et al.* 1970). Howell *et al.* 1998 cultured Apple Freckle Scurf on the apple cultivar 'Red Delicious' and found that heat therapy (38ºC and16 hour photoperiods for 70 or more days) eliminated the disease in 4 replicates.

8.7.1.4. Hazard identification conclusion

The accepted absence of Apple Freckle Scurf in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Freckle Scurf agent should be considered a potential hazard requiring further assessment.

8.7.2. Risk assessment

8.7.2.1. Entry assessment

There is little available information on the prevalence of Apple Freckle Scurf within infected *Malus* populations; although Jones & Aldwinckle (1990) report that it is not prevalent. The likelihood of the association of Apple Freckle Scurf with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Freckle Scurf agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Freckle Scurf agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.7.2.2. Assessment of exposure and establishment

Should the Apple Freckle Scurf agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.7.2.3. Consequence assessment

Spread

The hosts of Apple Freckle Scurf agent (apple) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Freckle Scurf is therefore considered low.

Economic consequences

Symptoms appear mostly on bark, with fruit and leaves not recorded as developing no diagnostic symptoms. No report was found on the effect on fruit quality or yield loss. There are unlikely to be any market access issues resulting from Apple Freckle Scurf disease in an apple orchard. The potential economic impact of Apple Freckle Scurf on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Freckle Scurf agent, namely localised bark necrosis and tree decline, while being of potential concern in commercial production, are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Freckle Scurf agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Freckle Scurf agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Freckle Scurf agent is not known to be of any significance to human health.

8.7.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Freckle Scurf has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.7.2.5. Risk estimation

The likelihood estimate is low to moderate that Apple Freckle Scurf would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Freckle Scurf that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Freckle Scurf associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.7.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Freckle Scurf. As such this risk assessment should be reviewed once further relevant information becomes available.

8.7.3. Risk management

8.7.3.1. Risk evaluation

Since the risk estimate for Apple Freckle Scurf agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.7.3.2. Option evaluation

There are conceivably a number of management options available for Apple Freckle Scurf on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Freckle Scurf;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Freckle Scurf;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on 3- to 4-year-old wood, woody indexing on the *Malus* cultivar 'Stayman Winesap' or 'Red Delicious' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical or graft inoculation of Apple Freckle Scurf infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 4-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Freckle Scurf.

Inspection of mother plants

As disease symptoms are expressed on 3- to 4-year-old wood, inspections should occur over a minimum of three growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Freckle Scurf. Assuming mother plants are inspected over a 4-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Freckle Scurf.

8.7.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research,* June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Cheney P W, Lindner R C, Parish C L (1970) Two graft-transmissible bark diseases of Apple. *Plant Disease Reporter* 54: pgs 44-48.

Howell W E, Burgess J, Mink G I, Zhang Y P, Skrzeczkowski L J (1998) Elimination of apple fruit and bark deforming agents by heat therapy. *Acta Horticulturae* 472: pgs 641-646.

Jones A L, Aldwinckle H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.8. Apple green dimple and ring blotch agent

8.8.1. Hazard identification

8.8.1.1. Aetiologic agent

Apple Green Dimple and Ring Blotch is a disease of unknown aetiology (WSU 2003).

8.8.1.2. New Zealand status

Apple Green Dimple and Ring Blotch agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.8.1.3. Biology and epidemiology

The occurrence of Apple Green Dimple and Ring Blotch was reported in the United States of America as early as 1939, but it was only described as a virus disease in 1955. Its relationship to virus diseases causing spots on apple is not yet clear. Symptoms include naturally infected *Malus pumila* cultivar 'Duchess' trees producing fruit that is covered by green spots. Fruit of 'Golden Delicious' and of graft-inoculated 'Lord Lambourne' develop russet rings and spots. There are no records of leaves or bark developing diagnostic symptoms (WSU 2003). The Apple Green Dimple and Ring Blotch agent is transmitted from woody plant to woody plant by grafting, budding and chip budding (Németh, 1986). The incubation period for disease development is usually 2 to 3 years, but if fruiting spurs taken from healthy 'Duchess' trees are grafted onto infected rootstocks the symptoms appear on the fruit in the same year (Németh, 1986).

Apple Green Dimple and Ring Blotch is considered absent from Canada and Mexico, and present in the eastern USA (NAPPO 2004, Németh 1986).

8.8.1.4. Hazard identification conclusion

The accepted absence of Apple Green Dimple and Ring Blotch in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Green Dimple and Ring Blotch agent should be considered a potential hazard requiring further assessment.

8.8.2. Risk assessment

8.8.2.1. Entry assessment

There is little available information on the prevalence of Apple Green Dimple and Ring Blotch within infected *Malus* populations. The likelihood of the association of Apple Green Dimple and Ring Blotch with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Green Dimple and Ring Blotch agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Green Dimple and Ring Blotch agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.8.2.2. Assessment of exposure and establishment

Should the Apple Green Dimple and Ring Blotch agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.8.2.3. Consequence assessment

Spread

The hosts of Apple Green Dimple and Ring Blotch agent (apples) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Green Dimple and Ring Blotch is therefore considered low.

Economic consequences

Németh considers Apple Green Dimple and Ring Blotch not to be of any economic importance (Németh, 1986). However should the crop trees of susceptible cultivars be infected, the quality and yield of the crop production would be to some extent affected. The potential economic impact of Apple Green Dimple and Ring Blotch on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Green Dimple and Ring Blotch agent, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Green Dimple and Ring Blotch agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Green Dimple and Ring Blotch agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Green Dimple and Ring Blotch agent is not known to be of any significance to human health.

8.8.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Green Dimple and Ring Blotch has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.8.2.5. Risk estimation

The likelihood estimate is low that Apple Green Dimple and Ring Blotch would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Green Dimple and Ring Blotch that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Green Dimple and Ring Blotch associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.8.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Green Dimple and Ring Blotch. As such this risk assessment should be reviewed once further relevant information becomes available.

8.8.3. Risk management

8.8.3.1. Risk evaluation

Since the risk estimate for Apple Green Dimple and Ring Blotch agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.8.3.2. Option evaluation

There are conceivably a number of management options available for Apple Green Dimple and Ring Blotch on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Green Dimple and Ring Blotch;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Green Dimple and Ring Blotch;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on 2- to 3-year-old wood, woody indexing on the *Malus* cultivars ‘Duchess’, ‘Golden Delicious’ or ‘Lord Lambourne’ should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Green Dimple and Ring Blotch infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Green Dimple and Ring Blotch.

Inspection of mother plants

As disease symptoms are expressed on 2- to 3-year-old wood, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple Green Dimple and Ring Blotch. Assuming mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Green Dimple and Ring Blotch.

8.8.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.9. Apple junction necrotic pitting agent

8.9.1. Hazard identification

8.9.1.1. Aetiologic agent

Apple Junction Necrotic Pitting is a disease of unknown aetiology.

8.9.1.2. New Zealand status

Apple Junction Necrotic Pitting agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.9.1.3. Biology and epidemiology

Symptoms appear only on indicator plants, although the pathogen causes latent infection in commercial varieties. In the crab apple cultivar 'Virginia Crab', a characteristic line of pits encircling the junction of the rootstock and scion is matched by necrotic phloem pegs. The line of pegs is not accompanied by stem pitting or grooving. Necrotic pitting and stem pitting infections often occur together at the junction. Fruit do not develop diagnostic symptoms (Németh 1986, Welsh & Uyemoto 1980, WSU 2003). Apple Junction Necrotic Pitting is reported though rarely found in North America (Welsh & Uyemoto 1980, WSU 2003).

8.9.1.4. Hazard identification conclusion

The accepted absence of Apple Junction Necrotic Pitting in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Junction Necrotic Pitting agent should be considered a potential hazard requiring further assessment.

8.9.2. Risk assessment

8.9.2.1. Entry assessment

There is little available information on the prevalence of Apple Junction Necrotic Pitting within infected *Malus* populations, although WSU (2003) report that it is rarely found. The likelihood of the association of Apple Junction Necrotic Pitting with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Junction Necrotic Pitting agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Junction Necrotic Pitting agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.9.2.2. Assessment of exposure and establishment

Should the Apple Junction Necrotic Pitting agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.9.2.3. Consequence assessment

Spread

The hosts of Apple Junction Necrotic Pitting agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Junction Necrotic Pitting is therefore considered low.

Economic consequences

Symptoms appear mostly on bark, with fruit developing no diagnostic symptoms. No report was found on the effect on fruit quality or yield loss. There are unlikely to be any market access issues resulting from Apple Junction Necrotic Pitting disease in an apple orchard. The potential economic impact of Apple Junction Necrotic Pitting on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Junction Necrotic Pitting agent, namely localised graft necrosis, while being of potential concern in commercial production, will be on no concern in natural ecosystems where grafting does not occur. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Junction Necrotic Pitting agent lowering tree vigour. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Junction Necrotic Pitting agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Junction Necrotic Pitting agent is not known to be of any significance to human health.

8.9.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Junction Necrotic Pitting has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.9.2.5. Risk estimation

The likelihood estimate is low that Apple Junction Necrotic Pitting would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Junction Necrotic Pitting that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Junction Necrotic Pitting associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits

they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.9.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Junction Necrotic Pitting. As such this risk assessment should be reviewed once further relevant information becomes available.

8.9.3. Risk management

8.9.3.1. Risk evaluation

Since the risk estimate for Apple Junction Necrotic Pitting agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.9.3.2. Option evaluation

There are conceivably a number of management options available for Apple Junction Necrotic Pitting on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Junction Necrotic Pitting;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Junction Necrotic Pitting;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on two-year-old wood, woody indexing on the *Malus* cultivar 'Virginia Crab' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical inoculation of Apple Junction Necrotic Pitting infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Junction Necrotic Pitting.

Inspection of mother plants

As disease symptoms of Apple Junction Necrotic Pitting are not expressed on commercial cultivars of apple, inspections of such material would not be considered an effective phytosanitary measure against this disease.

8.9.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Németh, M V (1986) *Virus, mycoplasma and rickettsia diseases of fruit trees.* Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

Welsh MF, Uyemoto JK (1980) Differentiation of Syndromes Caused in Apple by Graft-Transmissible, Xylem-Affecting Agents. Phytopathology 70:349-352.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.10. Apple McIntosh depression agent

8.10.1. Hazard identification

8.10.1.1. Aetiologic agent

Apple McIntosh Depression is a disease of unknown aetiology.

8.10.1.2. New Zealand status

Apple McIntosh Depression agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.10.1.3. Biology and epidemiology

The disease was described in the United States of America as severely affecting the fruits of infected trees (WSU 2003, NAPPO 2004). On leaves of infected *Malus pumila* cultivar 'McIntosh' trees severe mosaic symptoms appear. The leaf blade is often distorted as a result of marginal crinkle. Irregular depressions, which render the fruit flat from one or both sides, appear by early August. The red colouring of mature fruit develops earlier in the depressions than in general (WSU 2003).

The mosaic symptoms appearing on the leaves of infected trees can be confused with the symptoms of Apple Mosaic; the latter, however, does not cause leaf deformations (Németh 1986). The incubation period for the disease is recorded as being 16 months (unknown reference). Apple McIntosh Depression is rarely found in North America (WSU 2003).

8.10.1.4. Hazard identification conclusion

The accepted absence of Apple McIntosh Depression in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple McIntosh Depression agent should be considered a potential hazard requiring further assessment.

8.10.2. Risk assessment

8.10.2.1. Entry assessment

There is little available information on the prevalence of Apple McIntosh Depression within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the association of Apple McIntosh Depression with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple McIntosh Depression agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple McIntosh Depression agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.10.2.2. Assessment of exposure and establishment

Should the Apple McIntosh Depression agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.10.2.3. Consequence assessment

Spread

The hosts of Apple McIntosh Depression agent (*Malus*) are readily available throughout New Zealand. The disease is likely to be graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple McIntosh Depression is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit and leaves, with stems developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple McIntosh Depression disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple McIntosh Depression on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple McIntosh Depression agent, namely localised fruit and leaf necrosis and deformation, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple McIntosh Depression agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple McIntosh Depression agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple McIntosh Depression agent is not known to be of any significance to human health.

8.10.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple McIntosh Depression has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.10.2.5. Risk estimation

The likelihood estimate is low that Apple McIntosh Depression would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple McIntosh Depression that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple McIntosh Depression associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

Given that level of assessed risk from Apple McIntosh Depression is low at every point in the assessment, and there is no evidence to suggest this disease has had significant impacts at any time, the conclusion that the risk is non-negligible should be qualified by the high level of uncertainty.

8.10.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple McIntosh Depression. As such this risk assessment should be reviewed once further relevant information becomes available.

8.10.3. Risk management

8.10.3.1. Risk evaluation

Since the risk estimate for Apple McIntosh Depression agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.10.3.2. Option evaluation

There are conceivably a number of management options available for Apple McIntosh Depression on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple McIntosh Depression;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple McIntosh Depression;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

The level of assessed risk from Apple McIntosh Depression is low at every point in the assessment, and there is no evidence to suggest this disease has had significant impacts at any time. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept this level of risk, given the benefits they may potential receive from importing such material.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As the disease incubation period is believed to be 16 months, woody indexing on the *Malus* cultivar 'McIntosh' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods and fruit set.

There is currently no information on the reliability of mechanical inoculation of Apple McIntosh Depression infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple McIntosh Depression.

Inspection of mother plants

As the disease incubation period is believed to be 16 months, inspections should occur over a minimum of two growing seasons that include autumn and summer growing periods and fruit set. There is currently no information on the sensitivity of inspections for mother plants for symptom expression of Apple McIntosh Depression. Assuming mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple McIntosh Depression.

8.10.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.11. Apple narrow leaf agent

8.11.1. Hazard identification

8.11.1.1. Aetiologic agent

Apple Narrow Leaf is a disease of unknown aetiology.

8.11.1.2. New Zealand status

Apple Narrow Leaf agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.11.1.3. Biology and epidemiology

Apple Narrow Leaf was first described as a genetic disorder on apple cultivar 'Worcester Pearmain' in 1963 and was reported to be perpetuated through grafting from infected trees (Larsen 1977). Larsen (1977) demonstrated that Apple Narrow Leaf produced symptoms in *Malus* x *robusta* (crab apple) but not in the usual indicator cultivars (e.g. 'Golden Delicious'), and the agent responsible was eliminated by heat therapy at 34ºC for 14 and 17 weeks.

Leaves of symptomatic trees are small and narrow, and some even strap like. While normal leaves may be found on the branches where most other leaves were narrow, generally whole branches are affected. Symptoms tend to be less distinctive with age, the strongest symptoms occurring in the second year after infection (Larsen 1977, WSU 2003).

Apple Narrow Leaf reported though rarely found and is latent in most commercial apple cultivars in North America and Europe (Larsen 1977, WSU 2003).

8.11.1.4. Hazard identification conclusion

The accepted absence of Apple Narrow Leaf in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Narrow Leaf agent should be considered a potential hazard requiring further assessment.

8.11.2. Risk assessment

8.11.2.1. Entry assessment

There is little available information on the prevalence of Apple Narrow Leaf within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the association of Apple Narrow Leaf with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Narrow Leaf agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Narrow Leaf agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.11.2.2. Assessment of exposure and establishment

Should the Apple Narrow Leaf agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.11.2.3. Consequence assessment

Spread

The hosts of Apple Narrow Leaf agent (*Malus*) are readily available throughout New Zealand. The disease is likely to be graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Narrow Leaf is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit and leaves, with stems developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Narrow Leaf disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple Narrow Leaf on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Narrow Leaf agent, namely localised leaf deformation, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Narrow Leaf agent making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Narrow Leaf agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Narrow Leaf agent is not known to be of any significance to human health.

8.11.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Narrow Leaf has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.11.2.5. Risk estimation

The likelihood estimate is low that Apple Narrow Leaf would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Narrow Leaf that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Narrow Leaf associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept this level of risk, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

8.11.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Narrow Leaf. As such this risk assessment should be reviewed once further relevant information becomes available.

8.11.3. Risk management

8.11.3.1. Risk evaluation

Since the risk estimate for Apple Narrow Leaf agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.11.3.2. Option evaluation

There are conceivably a number of management options available for Apple Narrow Leaf on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** No phytosanitary measures required if the non-negligible level of risk is considered acceptable;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Narrow Leaf;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Narrow Leaf;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

No phytosanitary measures required

The level of assessed risk from Apple Narrow Leaf is low at every point in the assessment, and there is no evidence to suggest this disease has had significant impacts at any time. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept this level of risk, given the benefits they may potential receive from importing such material.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed 2 years after inoculation of symptomatic plants, woody indexing on the *Malus* cultivars or hybrids known to be symptomatic (e.g. the apple cultivar ‘Worcester Pearmain’, or *Malus* x *robusta*) should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Narrow Leaf infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Narrow Leaf.

Inspection of mother plants

As Apple Narrow Leaf is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Narrow Leaf.

8.11.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Larsen E C (1977) Latent apple narrow leaf transmissible to *Malus* X *robusta* (Carr.) Rehd., cl.5. *Tidsskrift for Planteavl* 81: pgs 359-364.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “*Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.12. Apple necrosis agent

8.12.1. Hazard identification

8.12.1.1. Aetiologic agent

Apple Necrosis is a disease of unknown aetiology (WSU 2003).

8.12.1.2. New Zealand status

Apple Necrosis agent is not known to be present in New Zealand (Pearson *et al.* 2006, PPIN 2009)

8.12.1.3. Biology and epidemiology

Apple Necrosis disease and an associated virus were first reported in Japan by Tokyo University researchers, Drs. Namba, Yamashita, Doi, and Yora (See *Annals of the Phytopathological Society of Japan* 40:80 (1982)). According to this abstract and one leaflet in "Dictionary on Viruses Occurring in Japan", symptoms of the disease first appeared on cultivar 'Starking Delicious' apple trees in Niigata prefecture during 1977. Infected trees exhibited necrotic spots (several millimetres in diameter) on new leaves during the spring and early summer (WSU 2003).

A virus was isolated from Apple Necrosis disease affected tissue onto *C. amaranticolar*. The associated particles were observed in cytoplasm of apple leaves using an electron microscope. It has not been confirmed whether the isolated virus causes Apple Necrosis disease. Back-inoculation of the virus to trees has not been attempted. Also, no graft transmission tests have been conducted with Apple Necrosis disease. The occurrence of the disease in Japan seems to be rare and its symptoms have not been observed since it was first reported. Consequently, the existence of apple necrosis disease in Japan has not been formally recognized by the Phytopathological Society of Japan (WSU 2003).

8.12.1.4. Hazard identification conclusion

Given the level of uncertainty around the legitimacy of Apple Necrosis disease, and the absence of any substantial understanding of its biology or epidemiology, it is recommended that this disease of unknown aetiology not be considered a potential hazard in this risk analysis.

8.12.1.5. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Necrosis. As such this risk assessment should be reviewed once further relevant information becomes available.

8.12.2. References

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.13. Apple necrotic spot & mottle agent

8.13.1. Hazard identification

8.13.1.1. Aetiologic agent

Apple Necrotic Spot and Mottle is a disease of unknown aetiology.

8.13.1.2. New Zealand status

Apple Necrotic Spot and Mottle agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.13.1.3. Biology and epidemiology

WSU (2003) state that Apple Necrotic Spot and Mottle disease is reported though rarely found and graft transmitted, but provides no further information. NAPPO (2004) list Apple Necrotic Spot and Mottle agent as being absent from North America (Canada, USA and Mexico). Sharma *et al*. (1979) reported the presence of Apple Necrotic Spot and Mottle disease in India. No further information was identified.

8.13.1.4. Hazard identification conclusion

Given the level of uncertainty around the legitimacy of Apple Necrotic Spot and Mottle disease, and the absence of any substantial understanding of its biology or epidemiology, it is recommended that this disease of unknown aetiology not be considered a potential hazard in this risk analysis.

8.13.1.5. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Necrotic Spot and Mottle. As such this risk assessment should be reviewed once further relevant information becomes available.

8.13.2. Reference

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

Sharma DC, Giri BK, Verma LR (1979) Additional viral/viral like diseases of temperate fruits in Simla Hills (Himachal Pradesh - India). IARI Regional Sta., Flowerdale., Simla, India: 7 pp.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.14. Apple Newton wrinkle agent

8.14.1. Hazard identification

8.14.1.1. Aetiologic agent

Apple Newton Wrinkle is a disease of unknown aetiology.

8.14.1.2. New Zealand status

Apple Newton Wrinkle agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.14.1.3. Biology and epidemiology

In the late 1960's in Canada a new disorder of the 'Newtown' cultivar was observed, which appeared only if the scions were top-grafted onto 'Gano' cultivar. The agent is therefore essentially a latent agent of the disease. Although the fruit symptoms produced in 'Newtown' resemble Apple Green Crinkle, based on other characteristics, they are not considered identical. It is also differentiated from Apple Star Crack Virus (Németh 1986). Initial symptoms appear as depressions and pits followed by mild russetting. Fruits are stunted and malformed with green strips in the flesh, which lead to the ovary. Minute-sized fruits, which develop from the base of the leaf petioles, are characteristic of the disease. Leaves are not reported to develop diagnostic symptoms (Németh 1986, WSU 2003).

The period of incubation for this disease is reported to be 2 years. Indicator plant, *Malus pumila* cultivar 'Newtown', displays fruit symptoms described above and the formation of small apples on the leaf petioles (Németh 1986). Apple Newton Wrinkle is only reported in Canada affecting two *Malus pumila* cultivars ('Newtown', with a latent infection in 'Gano') (NAPPO 2004, Németh 1986).

8.14.1.4. Hazard identification conclusion

The accepted absence of Apple Newton Wrinkle in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Newton Wrinkle agent should be considered a potential hazard requiring further assessment.

8.14.2. Risk assessment

8.14.2.1. Entry assessment

There is little available information on the prevalence of Apple Newton Wrinkle within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the association of Apple Newton Wrinkle with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Newton Wrinkle agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Newton Wrinkle agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.14.2.2. Assessment of exposure and establishment

Should the Apple Newton Wrinkle agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.14.2.3. Consequence assessment

Spread

The hosts of Apple Newton Wrinkle agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Newton Wrinkle is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit, with stems and leaves developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Newton Wrinkle disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple Newton Wrinkle on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Newton Wrinkle agent, namely localised fruit necrosis and deformation, while being of potential concern in commercial production, are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Newton Wrinkle agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Newton Wrinkle agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Newton Wrinkle agent is not known to be of any significance to human health.

8.14.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Newton Wrinkle has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.14.2.5. Risk estimation

The likelihood estimate is low that Apple Newton Wrinkle would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Newton Wrinkle that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Newton Wrinkle associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.14.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Newton Wrinkle. As such this risk assessment should be reviewed once further relevant information becomes available.

8.14.3. Risk management

8.14.3.1. Risk evaluation

Since the risk estimate for Apple Newton Wrinkle agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.14.3.2. Option evaluation

There are conceivably a number of management options available for Apple Newton Wrinkle on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Newton Wrinkle;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Newton Wrinkle;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed in two-year-old fruit bearing trees, woody indexing on the *Malus pumila* cultivar 'Newtown' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of mechanical inoculation of Apple Newton Wrinkle infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Newton Wrinkle.

Inspection of mother plants

As Apple Newton Wrinkle is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Narrow Leaf (e.g. the *Malus pumila* cultivar 'Newtown'). Assuming symptomatic mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Newton Wrinkle.

8.14.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.15. Apple painted face agent

8.15.1. Hazard identification

8.15.1.1. Aetiologic agent

Apple Painted Face is a disease of unknown aetiology.

8.15.1.2. New Zealand status

Apple Painted Face agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.15.1.3. Biology and epidemiology

WSU (2003) (and BA 2002) state that Apple Painted Face disease is reported though rarely found and graft transmitted but provides no further information. NAPPO (2004) list Apple Painted Face agent as being absent from North America (Canada, USA and Mexico).

The only original record found was in Wang (1958) who described a graft and root transmitted disease of dwarf apples in China. The described symptoms of Painted Face disease of the dwarf apples included two forms: the 1st systemic, the whole tree becoming infected during fruit bearing, while in the 2nd clear symptoms develop only after several years of fruit bearing, usually starting with partial infection of branches and twigs, and becoming systemic within a few years. Most symptoms develop after the surface of the fruit has become coloured, with bright red and green spots alternating, and green or yellow-green roughly circular patches of a few to over 10 mm. sometimes coalescing to form bands. The green part of the surface of the fruit is concave and that with the basic colour convex (Wang 1958).

The author noted that the symptoms were very similar to those of ‘Dapple Apple’ (Wang 1958) which is now known to be caused by Apple Scar Skin viroid (ASSVd).

No further information was identified.

8.15.1.4. Hazard identification conclusion

The lack of any further reports of this disease in the literature and the similarity of symptoms to those caused by ASSVd suggest that this disease may have been caused by a viroid closely related to the ASSVd. Section 6.3 analyses the biosecurity risks associated with imported *Malus* nursery stock and ASSVd. The lack of any further information on the biology of Apple Painted Face agent suggests that the risk description and analysis of phytosanitary measures provided in section 6.3 should also be sufficient for Apple Painted Face agent and as such no further analysis of risk is justified.

8.15.1.5. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Painted Face. As such this risk assessment should be reviewed once further relevant information becomes available.

8.15.2. References

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

Wang TH (1958) Report on investigations of Apple virus (painted face) in Shansi. *Zhibing zhishi* 2: 108-111 (Abstract only).

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.16. Apple pustule canker agent

8.16.1. Hazard identification

8.16.1.1. Aetiologic agent

Apple Pustule Canker is a disease of unknown aetiology.

8.16.1.2. New Zealand status

Apple Pustule Canker agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.16.1.3. Biology and epidemiology

Apple Pustule Canker disease was first observed in 1959 in apple orchards on the West Coast of the United States of America and Cheney *et al*. described the disease in 1970 (Cheney *et al*. 1970). Two distinct symptoms of pustule canker are observed on 'Delicious' cultivars (include cultivar 'Red Delicious'7). Small, raised bumps form on 2- to 3-year-old limbs. The tissue underlying these bumps is necrotic. This stage resembles measles (Internal Bark Necrosis). On older wood, the bumps are up to 2.5 cm in diameter and 1 cm high. These pustules contain large pockets of necrotic tissue under a layer of apparently normal tissue. No gumming or bleeding has been observed. The pustules collapse and the paper-thin, orange surface layer peels off. The underlying tissue dries, cracks, and peels, leaving a depression. Isolated small bumps form large, irregular cankers. The margins of the cankers are sharply delineated from the adjacent bark (Jones & Aldwinckle 1990). Fruit and leaves do not develop diagnostic symptoms in most apple cultivars (WSU 2003).

This disease is a graft transmissible bark disorder of unknown aetiology, which is or will be a minor disease, because it can be eliminated from nursery stock by budwood certification programs (Jones & Aldwinckle 1990, WSU 2003). The incubation period can last as long as 3 to 4 years (Németh 1986).

Possibility of confusion with other diseases and injuries may occur. For instance symptoms may be confused with the bark disorders of trees suffering from boron deficiency or manganese poisoning; in the latter two, however, no scaly bark necrosis appears which is typical of pustule canker (Németh, 1986). Apple Pustule Canker is reported as being present in the western USA (Németh, 1986), but absent from Canada and Mexico (NAPPO 2004) and Australia (BA 2002). The natural host of Apple Pustule Canker is *Malus pumila* cultivar 'Red Delicious', but other hosts include 'Okanoma Delicious' and 'Starking Delicious'.

8.16.1.4. Hazard identification conclusion

The accepted absence of Apple Pustule Canker in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Pustule Canker agent should be considered a potential hazard requiring further assessment.

8.16.2. Risk assessment

8.16.2.1. Entry assessment

There is little available information on the prevalence of Apple Pustule Canker within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the

7 Apple cultivar 'Delicious' sports include 'Red Delicious' varieties (All about apples 2009).

association of Apple Pustule Canker with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Pustule Canker agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Pustule Canker agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.16.2.2. Assessment of exposure and establishment

Should the Apple Pustule Canker agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.16.2.3. Consequence assessment

Spread

The hosts of Apple Pustule Canker agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Pustule Canker is therefore considered low.

Economic consequences

Symptoms appear mostly on stems, with fruit and leaves developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Pustule Canker disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple Pustule Canker on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Pustule Canker agent, namely localised bark or wood necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Pustule Canker agent lowering fruit yield or making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Pustule Canker agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Pustule Canker agent is not known to be of any significance to human health.

8.16.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Pustule Canker has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.16.2.5. Risk estimation

The likelihood estimate is low that Apple Pustule Canker would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Pustule Canker that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Pustule Canker associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.16.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Pustule Canker. As such this risk assessment should be reviewed once further relevant information becomes available.

8.16.3. Risk management

8.16.3.1. Risk evaluation

Since the risk estimate for Apple Pustule Canker agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.16.3.2. Option evaluation

There are conceivably a number of management options available for Apple Pustule Canker on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Pustule Canker;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Pustule Canker;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on 3- to 4-year-old wood, woody indexing on the *Malus* cultivars 'Red Delicious', 'Okanoma Delicious' or 'Starking Delicious' should be followed by inspections over a minimum of four growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Pustule Canker infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 4-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Pustule Canker.

Inspection of mother plants

As Apple Pustule Canker is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Pustule Canker (e.g. the *Malus* cultivars 'Red Delicious', 'Okanoma Delicious' or 'Starking Delicious'). Assuming symptomatic mother plants are inspected over a 4-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Pustule Canker.

8.16.4. References

All About Apples (2009) All about apples. Web based information available at http://www.allaboutapples.com/index.htm

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Cheney, P W; Lindner, R C; Parish, C L (1970) Two graft-transmissible bark diseases of Apple. Plant Disease Reporter 54(1): 44-48.

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and

Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.17. Apple red ring agent

8.17.1. Hazard identification

8.17.1.1. Aetiologic agent

Apple Red Ring is a disease of unknown aetiology.

8.17.1.2. New Zealand status

Apple Red Ring agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.17.1.3. Biology and epidemiology

Apple Red Ring disease was described in the United States of America in 1967 (Németh, 1986). *Malus pumila* cultivar 'Red Delicious' fruit develop red rings on their skins prior to the formation of the natural red colour. The intensity of these rings becomes less conspicuous towards maturation (WSU 2003) (Németh, 1986). While the causal agent is unknown (BA 2002, WSU 2003), Apple Red Ring has been reported as being associated with trees infected with Apple stem grooving virus, Apple stem pitting virus and Apple chlorotic leaf spot virus (Németh, 1986).

The disease can be transmitted from one woody plant to another by budding, grafting and chip budding, with an incubation period of 1 to 2 years (Németh, 1986). Apple Red Ring is reported as being present in the USA (Németh, 1986), but absent from Canada and Mexico (NAPPO 2004) and Australia (BA 2002).

8.17.1.4. Hazard identification conclusion

The accepted absence of Apple Red Ring in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Red Ring agent should be considered a potential hazard requiring further assessment.

8.17.2. Risk assessment

8.17.2.1. Entry assessment

There is little available information on the prevalence of Apple Red Ring within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the association of Apple Red Ring with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Red Ring agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Red Ring agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.17.2.2. Assessment of exposure and establishment

Should the Apple Red Ring agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.17.2.3. Consequence assessment

Spread

The hosts of Apple Red Ring agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Red Ring is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit, with stems and leaves developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Red Ring disease in an apple orchard, though marketable fruit yield may decline. The potential economic impact of Apple Red Ring on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low. Identifying any alternative hosts would most likely first require identifying the causal agent.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Red Ring agent, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the v agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Red Ring agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Red Ring agent is not known to be of any significance to human health.

8.17.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Red Ring has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.17.2.5. Risk estimation

The likelihood estimate is low that Apple Red Ring would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Red Ring that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Red Ring associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits

they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.17.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Red Ring. As such this risk assessment should be reviewed once further relevant information becomes available.

8.17.3. Risk management

8.17.3.1. Risk evaluation

Since the risk estimate for Apple Red Ring agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.17.3.2. Option evaluation

There are conceivably a number of management options available for Apple Red Ring on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Red Ring;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Red Ring;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed the fruit of 1 to 2-year-old fruit bearing trees, woody indexing on the *Malus pumila* cultivar ‘Red Delicious’ should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Red Ring infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Red Ring.

Inspection of mother plants

As Apple Red Ring is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Red Ring (e.g. the *Malus pumila* cultivar ‘Red Delicious’). Assuming symptomatic mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Red Ring.

8.17.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.18. Apple rosette agent

8.18.1. Hazard identification

8.18.1.1. Aetiologic agent

Apple Rosette is a disease of unknown aetiology (WSU 2003).

8.18.1.2. New Zealand status

Apple Rosette agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.18.1.3. Biology and epidemiology

Growth of *Malus pumila* trees infected by Apple Rosette is reduced and shoots are stunted with short internodes so that the leaves form rosettes. Leaves are small, brittle, curled upwards, and deeply serrated. Although flowering is seemingly normal, infected trees produce little or no fruit (Németh 1986, WSU 2003). The disease can be transmitted from one woody plant to another by budding and grafting, with an incubation period of 2 to 3 years (Nemeth 1986, WSU 2003). *Malus pumila* cultivar 'Belle de Bokskoop' could be used as indicator plant, with leaf symptoms described above (Németh, 1986).

Apple Rosette disease has been known by growers in Holland for 30-35 years, especially in older orchards, where the crop losses caused by the disease are quite high (Németh 1986). Apple Rosette is recorded as being present in Denmark, Italy, The Netherlands, USSR (Németh 1986), but absent from Canada, USA and Mexico (NAPPO 2004) and Australia (BA 2002).

8.18.1.4. Hazard identification conclusion

The accepted absence of Apple Rosette in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Rosette agent should be considered a potential hazard requiring further assessment.

8.18.2. Risk assessment

8.18.2.1. Entry assessment

There is little available information on the prevalence of Apple Rosette within infected *Malus* populations; although WSU (2003) report that it is rarely found. The likelihood of the association of Apple Rosette with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Rosette agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Rosette agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.18.2.2. Assessment of exposure and establishment

Should the Apple Rosette agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.18.2.3. Consequence assessment

Spread

The hosts of Apple Rosette agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Rosette is therefore considered low.

Economic consequences

Symptoms appear mostly on stems and leaves, with fruit developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Rosette disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple Rosette on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Rosette agent, namely localised leaf necrosis and reduced tree vigour, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Rosette agent lowering fruit yield or quality and making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Rosette agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Rosette agent is not known to be of any significance to human health.

8.18.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Rosette has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.18.2.5. Risk estimation

The likelihood estimate is low that Apple Rosette would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Rosette that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Rosette associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits

they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.18.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Rosette. As such this risk assessment should be reviewed once further relevant information becomes available.

8.18.3. Risk management

8.18.3.1. Risk evaluation

Since the risk estimate for Apple Rosette agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.18.3.2. Option evaluation

There are conceivably a number of management options available for Apple Rosette on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Rosette;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Rosette;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed over a 2 to 3-year-old period, woody indexing on the *Malus* cultivar 'Belle de Bokskoop' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Rosette infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Rosette.

Inspection of mother plants

As Apple Rosette is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Rosette (e.g. the *Malus pumila* cultivar 'Belle de Bokskoop'). Assuming symptomatic mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Rosette.

8.18.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.19. Apple rough skin agent

8.19.1. Hazard identification

8.19.1.1. Aetiologic agent

Apple Rough Skin is a disease of unknown aetiology (BA 2002, Jones & Aldwinckle 1990).

8.19.1.2. New Zealand status

Apple Rough Skin agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009).

8.19.1.3. Biology and epidemiology

Apple Rough Skin disease was first described in Holland. Symptoms on *Malus pumila* cultivars 'Belle de Boskoop' and 'Glorie van Holland' occur on leaves and fruit and are influenced by weather, with the best expression occurring during wet, cloudy spring conditions. The most conspicuous symptom is rough, dark brown, corky areas on the fruit, giving it a scabby appearance. The corky patches may appear as single spots or may form partial rings. The skin of the fruit is not cracked or broken. Under cooler growing conditions star-shaped cracks may form on the affected areas. The spots often crack open, on smooth-skinned cultivars, and the wounds look as if they have been punctured by a knife. The symptoms appear on the fruits of one or a few branches; later, the whole tree becomes infected. The leaf symptoms are flecking and puckering of the first spur leaves (Németh 1986, Jones & Aldwinckle 1990, WSU 2003). Symptoms on cultivar 'Golden Delicious' include rough, corky spots on the skin of the fruit (EPPO 2009).

The association with Apple Star Crack virus (ASCV) has not yet been proved. Contrary to ASCV, Apple Rough Skin does not cause necrosis of bark and shoot tips and as such it is regarded at present as a distinct disease (Németh, 1986). The possibility of confusion with injuries caused by chemical sprays may be likely. Damage from chemical sprays, however, appears mostly around the calyx and on the exposed, red side of the fruit and mostly in the outer parts of the tree crown. The spots caused by the disease occur both on the inner, less coloured and on the outer part of the fruits, and in all parts of the tree crown (Németh, 1986).

Apple Rough Skin disease can be transmitted from one woody plant to another by grafting, budding and chip budding. While very slow natural spread within the orchards was also observed, a vector has yet to be identified (Németh 1986, Jones & Aldwinckle 1990). It has been transmitted to *Malus baccata* 'fructo flavo' while *Malus pumila* cultivar 'Golden Delicious' is an indicator plant displaying the fruit symptoms described above (Németh, 1986).

Apple Rough Skin is recorded as being present in Australia, Austria, Belgium, former Czechoslovakia, Finland, FRG, Germany, Great Britain, India, Italy, The Netherlands, Norway, Poland, Switzerland, and USA (Németh 1986, BA 2002).

8.19.1.4. Hazard identification conclusion

The accepted absence of Apple Rough Skin in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Rough Skin agent should be considered a potential hazard requiring further assessment.

8.19.2. Risk assessment

8.19.2.1. Entry assessment

There is little available information on the prevalence of Apple Rough Skin within infected *Malus* populations. The likelihood of the association of Apple Rough Skin with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Rough Skin agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Rough Skin agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.19.2.2. Assessment of exposure and establishment

Should the Apple Rough Skin agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.19.2.3. Consequence assessment

Spread

The hosts of Apple Rough Skin agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. While no vector is known to transmit the disease, slow spread has been recorded in orchards. The likelihood of the spread of Apple Rough Skin is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit and leaves, with stems developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Rough Skin disease in an apple orchard, though marketable fruit yield may decline. The potential economic impact of Apple Rough Skin on the New Zealand horticultural sector should therefore be considered to have a moderate likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Rough Skin agent, namely localised fruit necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Rough Skin agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Rough Skin agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Rough Skin agent is not known to be of any significance to human health.

8.19.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Rough Skin has a moderate likelihood of causing low economic consequences and a low likelihood of causing low environmental consequences to New Zealand.

8.19.2.5. Risk estimation

The likelihood estimate is low that Apple Rough Skin would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Rough Skin that does enter would successfully establish in New Zealand, moderate that establishment would result in low economic consequences, and low that establishment would result in environmental consequences to New Zealand. As a result the risk estimate for Apple Rough Skin associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

8.19.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Rough Skin. As such this risk assessment should be reviewed once further relevant information becomes available.

8.19.3. Risk management

8.19.3.1. Risk evaluation

Since the risk estimate for Apple Rough Skin agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.19.3.2. Option evaluation

There are conceivably a number of management options available for Apple Rough Skin on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Rough Skin;
- **b.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Rough Skin;
- **c.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **d.** Inspection of mother plants.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed 2- to 3- years after inoculation, woody indexing on the *Malus* cultivar 'Golden Delicious' should be followed by inspections over a minimum of 3 growing seasons that include autumn and summer growing periods and fruit set.

There is currently no information on the reliability of graft inoculation of Apple Rough Skin infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Rough Skin.

Inspection of mother plants

As Apple Rough Skin is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Rough Skin (e.g. the *Malus* cultivars 'Golden Delicious', 'Belle de Boskoop' and 'Glorie van Holland'). Assuming symptomatic mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Rough Skin.

8.19.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research,* June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

EPPO (2009) Pathogen-tested material of *Malus*, *Pyrus* and *Cydonia*. EPPO Standards Certification Schemes. *European and Mediterranean Plant Protection Organization*: 15pp. Available online at http://archives.eppo.org/EPPOStandards/certification.htm

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

Németh, M V (1986) Virus, mycoplasma and rickettsia diseases of fruit trees. Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.20. Apple russet wart agent

8.20.1. Hazard identification

8.20.1.1. Aetiologic agent

Apple Russet Wart is a disease of unknown aetiology (WSU 2003).

8.20.1.2. New Zealand status

Apple Russet Wart agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.20.1.3. Biology and epidemiology

Apple Russet Wart disease was described in England in 1969 and is best characterized by russetted wart-like protuberances having superficial necrotic spots, which develop on the fruit surface. On *Malus* cultivar 'Golden Delicious' malformation of the fruit occurs, and on the immature fruit of 'Cox's Orange Pippin' necrotic russet rings appear after a 10-month incubation period. The leaves are smaller, lightly distorted with chlorotic rings, spots or necrotic spots. Symptoms not only appear on fruiting spurs, but on leaves of shoots formed during the summer months (Németh 1986, WSU 2003). Some symptoms resemble those of Apple Leaf Pucker, Apple Russet Ring, or Apple Green Crinkle, but the virus differs from them by its leaf symptoms.

Susceptible cultivars of *Malus* include 'Golden Delicious', 'Cox's Orange Pippin', and the M2 rootstock variety. Apple Rough Skin is recorded as being present in Austria, France, FRG, Great Britain, Hungary, Portugal, and Switzerland (Németh 1986) but absent from Australia (BA 2002).

8.20.1.4. Hazard identification conclusion

The accepted absence of Apple Russet Wart in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Russet Wart agent should be considered a potential hazard requiring further assessment.

8.20.2. Risk assessment

8.20.2.1. Entry assessment

There is little available information on the prevalence of Apple Russet Wart within infected *Malus* populations. The likelihood of the association of Apple Russet Wart with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Russet Wart agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Russet Wart agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.20.2.2. Assessment of exposure and establishment

Should the Apple Russet Wart agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.20.2.3. Consequence assessment

Spread

The hosts of Apple Russet Wart agent (*Malus*) are readily available throughout New Zealand. The disease is likely to be graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Rosette is therefore considered low.

Economic consequences

Symptoms appear mostly on fruit and leaves, with stems developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Russet Wart disease in an apple orchard, though marketable fruit yield may decline. The potential economic impact of Apple Russet Wart on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Russet Wart agent, namely localised fruit and leaf necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Russet Wart agent lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Russet Wart agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Russet Wart agent is not known to be of any significance to human health.

8.20.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Russet Wart has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.20.2.5. Risk estimation

The likelihood estimate is low that Apple Russet Wart would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Russet Wart that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Russet Wart associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

8.20.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Russet Wart. As such this risk assessment should be reviewed once further relevant information becomes available.

8.20.3. Risk management

8.20.3.1. Risk evaluation

Since the risk estimate for Apple Russet Wart agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.20.3.2. Option evaluation

There are conceivably a number of management options available for Apple Russet Wart on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Russet Wart;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Russet Wart;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. In the case of Apple Russet Wart there is little available information on how this disease spreads and as such impacts could be wider than the importing industries.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed 1 to 2 years after inoculation, woody indexing on the *Malus* cultivars ‘Golden Delicious’ or ‘Cox’s Orange Pippin’ should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods and fruit set.

There is currently no information on the reliability of graft inoculation of Apple Russet Wart infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Russet Wart.

Inspection of mother plants

As Apple Russet Wart is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Russet Wart (e.g. the *Malus* cultivars ‘Golden Delicious’ and ‘Cox’s Orange Pippin’). Assuming symptomatic mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Russet Wart.

8.20.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Németh, M V (1986) *Virus, mycoplasma and rickettsia diseases of fruit trees.* Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. *Pome Fruit-Virus Detection Procedures* (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.21. Apple star crack agent

8.21.1. Hazard identification

8.21.1.1. Aetiologic agent

Apple Star Crack is a disease of unknown aetiology (WSU 2003).

8.21.1.2. New Zealand status

Apple Star Crack agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.21.1.3. Biology and epidemiology

Apple Star Crack disease was first described in the UK in 1955. Because the disease is graft-transmissible, it is assumed to be caused by a virus, or virus-like organism, however the morphology, physical and chemical properties of the causal agent are (as yet) unknown. The possible relationship of apple star crack to a number of other similar transmissible fruit disorders, such as Apple Rough Skin and Apple Horse-Shoe Wound agent, have yet to be determined (Németh 1986).

Apple Star Crack disease usually occurs in the presence of several latent virus infections, such as apple chlorotic leaf spot, apple stem pitting, and epinasty and decline (CPC 2007). Symptoms begin with the development of bark necrosis around the buds of one-year-old shoots in January. Bark symptoms can vary from rough bark spots to open cankers. Shoot tips often dieback, which is followed by additional growth from the lower buds. Bud break can be premature or delayed and flowering can be abnormal (WSU 2003). Affected trees of some cultivars (e.g. ‘Cox's Orange Pippin’, ‘Queen Cox’, and ‘James Grieve’) often come into growth later in the spring than healthy trees, sometimes by as much as 3 weeks. Others may leaf out a few days earlier than healthy trees (e.g. ‘Idared’, ‘Hardispur Delicious’, and ‘Merton Beauty’) (CPC 2007).

Infected trees are frequently weak, producing fewer fruits, often with star-shaped cracks in the skin, mainly towards the calyx end. Severe distortion, cracking, and reduction in fruit size can occur. Some cultivars may only show mild pitting or simple rough fruit. In the autumn, young leaves on the shoots become slightly chlorotic and cupped, and these shoots may die back during winter. Infected trees may be stunted (CPC 2007). Although the agent can cause extensive damage on infected trees, it does not spread within the orchard and, as it usually only occurs sporadically, the severity of its symptoms is not proportional to its economic importance (Németh 1986, CPC 2007). The most susceptible cultivars of *Malus pumila* are ‘Cox’s Orange Pippin’ and ‘Golden Delicious’. From among the 45 cultivars tested in an experiment in England, 28 showed fruit symptoms.

The incubation period can last 2-4 years before fruit symptoms appear (Németh 1986, CPC 2007). Plant parts liable to carry the pest in trade and transport include the stems, shoots, trunks, branches and wood, which bear the disease internally and is invisible (CPC 2007). There are no known vectors or other means of spread (Németh 1986, CPC 2007).

Apple Star Crack is recorded as being present in Asia (India, Iran, and Turkey), Europe (Belgium, former Czechoslovakia, Denmark, Finland, Former USSR, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Sweden, Switzerland, and United Kingdom), North America (Canada, Mexico, and USA) and Australia (WSU 2003, CPC 2007, BA 2002).

8.21.1.4. Hazard identification conclusion

The accepted absence of Apple Star Crack in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Star Crack agent should be considered a potential hazard requiring further assessment.

8.21.2. Risk assessment

8.21.2.1. Entry assessment

There is little available information on the prevalence of Apple Star Crack within infected *Malus* populations, although Németh 1986 notes that it usually only occurs sporadically. The likelihood of the association of Apple Star Crack with trees from which any *Malus* budwood is taken for export to New Zealand is therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Star Crack agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Star Crack agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.21.2.2. Assessment of exposure and establishment

Should the Apple Star Crack agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.21.2.3. Consequence assessment

Spread

The hosts of Apple Star Crack agent (*Malus*) are readily available throughout New Zealand. The disease is graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Star Crack is therefore considered low.

Economic consequences

Symptoms appear on fruit, leaves and stems. There are unlikely to be any market access issues resulting from Apple Star Crack disease in an apple orchard, though fruit yield may decline. Although the agent can cause extensive damage on infected trees, it does not spread within the orchard and, as it usually only occurs sporadically, the severity of its symptoms is not proportional to its economic importance (Németh 1986, CPC 2007). The potential economic impact of Apple Star Crack on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Star Crack agent, namely localised shoot necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Star Crack agent making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Star Crack agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Star Crack agent is not known to be of any significance to human health.

8.21.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Star Crack has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.21.2.5. Risk estimation

The likelihood estimate is low that Apple Star Crack would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Star Crack that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Star Crack associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.21.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Star Crack. As such this risk assessment should be reviewed once further relevant information becomes available.

8.21.3. Risk management

8.21.3.1. Risk evaluation

Since the risk estimate for Apple Star Crack agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.21.3.2. Option evaluation

There are conceivably a number of management options available for Apple Star Crack on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Star Crack;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Star Crack;

d. Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.

e. Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. Disease symptoms begin to appear about 1 year after inoculation, usually as bark lesions and shoot dieback. Flower and fruit symptoms appear 2 or more years after inoculation. Woody indexing on the *Malus* cultivars 'Golden Delicious' or 'Cox's Orange Pippin' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods and fruit set.

There is currently no information on the reliability of graft inoculation of Apple Star Crack infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Star Crack.

Inspection of mother plants

As Apple Star Crack is considered latent in many commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Star Crack (e.g. the *Malus pumila* cultivars 'Golden Delicious', 'Cox's Orange Pippin' etc). Assuming symptomatic mother plants are inspected over a 2-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Star Crack.

8.21.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (Malus) and Pear (Pyrus) Budwood. Biosecurity Australia; 68pp.

CPC (2005) Crop Protection Compendium on Internet. CAB INTERNATIONAL, Wallingford, UK; http://www.cabi.org/compendia/CPC/

Németh, M V (1986) *Virus, mycoplasma and rickettsia diseases of fruit trees.* Martinus Nijhoff Publishers, The Netherlands and Akademiai Kiado, Hungary; 841 pp.

NAPPO (2004) *Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and* Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) *Plant diseases recorded in New Zealand.* Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) "*Virus Free" Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001*. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.22. Apple transmissible internal bark necrosis agent

8.22.1. Hazard identification

8.22.1.1. Aetiologic agent

Apple Transmissible Internal Bark Necrosis is a disease of unknown aetiology (NAPPO 2004).

8.22.1.2. New Zealand status

Apple Transmissible Internal Bark Necrosis agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.22.1.3. Biology and epidemiology

There appears to be two types of internal bark necrosis:

(1) A non- infectious disorder caused by nutritional deficiencies (Jones & Aldwinkcle 1990); and

(2) A transmissible bark disorder of unknown aetiology that can be eliminated from nursery stock by budwood certification programs (Jones & Aldwinckle 1990).

The non-infectious disorder, otherwise know as Internal Bark Necrosis (IBN) or measles, is a serious disorder of apple trees grown in acid soils. It is primarily a problem of ‘Delicious’ and its sports. IBN results from manganese toxicity and is often associated with very acid soils, light-textured soils, and, sometimes, poorly drained soils containing appreciable amounts of readily available manganese (Jones & Aldwinckle 1990). The transmissible bark disorder is not particularly prevalent, has no known vectors, and is spread by infected budwood (Jones & Aldwinckle 1990).

Apple Transmissible Internal Bark Necrosis symptoms are superficially expressed on 2- to 3-year-old limbs of ‘Delicious’ and its sports (e.g. ‘Red Delicious’[8]) as raised spots in the bark, visible as dark areas or blackish necrotic spots under the bark. Dark, necrotic spots can be observed in the bark when it is cut. Occasionally, some dieback of small limbs is observed, which may be caused by partial girdling of the limb by the infected areas. Fruit do not develop diagnostic symptoms (Jones & Aldwinckle 1990, WSU 2003).

Apple Transmissible Internal Bark Necrosis is recorded as being present in USA (NAPPO 2004), but absent from Canada and Mexico (NAPPO 2004) and Australia (BA 2002).

8.22.1.4. Hazard identification conclusion

The accepted absence of Apple Transmissible Internal Bark Necrosis in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that the Apple Transmissible Internal Bark Necrosis agent should be considered a potential hazard requiring further assessment.

8.22.2. Risk assessment

8.22.2.1. Entry assessment

There is little available information on the prevalence of Apple Transmissible Internal Bark Necrosis within infected *Malus* populations; although Jones & Aldwinckle (1990) report that it is not particularly prevalent. The likelihood of the association of Apple Transmissible Internal Bark Necrosis with trees from which any *Malus* budwood is taken for export to New Zealand is

8 Apple cultivar ‘Delicious’ sports include ‘Red Delicious’ varieties (All about apples 2009).

therefore difficult to estimate but is unlikely to be high. The likelihood of survival of the Apple Transmissible Internal Bark Necrosis agent in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of the Apple Transmissible Internal Bark Necrosis agent into New Zealand with *Malus* nursery stock from infected populations is low and therefore non-negligible.

8.22.2.2. Assessment of exposure and establishment

Should the Apple Transmissible Internal Bark Necrosis agent be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

8.22.2.3. Consequence assessment

Spread

The hosts of Apple Transmissible Internal Bark Necrosis agent (*Malus*) are readily available throughout New Zealand. The disease is most likely graft-transmitted, thus it can be spread by human activities through budding and grafting. No vector is known to transmit the disease. The likelihood of the spread of Apple Transmissible Internal Bark Necrosis is therefore considered low.

Economic consequences

Symptoms appear mostly on stems, with fruit and leaves developing few diagnostic symptoms. There are unlikely to be any market access issues resulting from Apple Transmissible Internal Bark Necrosis disease in an apple orchard, though fruit yield may decline. The potential economic impact of Apple Transmissible Internal Bark Necrosis on the New Zealand horticultural sector should therefore be considered to have a low likelihood of being low.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Identifying any alternative hosts would most likely first require identifying the causal agent. Symptoms of disease caused by the Apple Transmissible Internal Bark Necrosis agent, namely localised bark necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by the Apple Transmissible Internal Bark Necrosis agent making trees less physically appealing. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of the Apple Transmissible Internal Bark Necrosis agent in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

The Apple Transmissible Internal Bark Necrosis agent is not known to be of any significance to human health.

8.22.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that Apple Transmissible Internal Bark Necrosis has a low likelihood of causing low economic consequences and low environmental consequences to New Zealand.

8.22.2.5. Risk estimation

The likelihood estimate is low that Apple Transmissible Internal Bark Necrosis would be associated with *Malus* nursery stock on entry into New Zealand, high that any Apple Transmissible Internal Bark Necrosis that does enter would successfully establish in New Zealand, and low that the establishment would result in low economic consequences and low environmental consequences to New Zealand. As a result the risk estimate for Apple Transmissible Internal Bark Necrosis associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

However, as discussed in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk, given the benefits they may potential receive from importing such material and their ability to manage any unwanted consequences should they occur.

8.22.2.6. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Apple Transmissible Internal Bark Necrosis. As such this risk assessment should be reviewed once further relevant information becomes available.

8.22.3. Risk management

8.22.3.1. Risk evaluation

Since the risk estimate for Apple Transmissible Internal Bark Necrosis agent associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

8.22.3.2. Option evaluation

There are conceivably a number of management options available for Apple Transmissible Internal Bark Necrosis on imported *Malus* nursery stock. The following risk management options are assessed:

- **a.** Risk mitigation undertaken by industry without official controls;
- **b.** Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of Apple Transmissible Internal Bark Necrosis;
- **c.** Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of Apple Transmissible Internal Bark Necrosis;
- **d.** Indexing of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility.
- **e.** Inspection of mother plants.

Mitigation by industry

As discussed above and in section 4.3.7.3, diseases that are only known to be mechanically and/or graft transmissible are unlikely to cause impacts outside of the industries directly benefiting from their importation. While the risk estimation is non-negligible, this risk analysis recognises that the risk bearers (industry) may accept responsibility for managing this risk without official controls, given the benefits they may potential receive from importing such material and their ability to effectively manage any unwanted consequences should they occur.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. It therefore should be considered that a reliable PFA determination may be unlikely. Should an appropriate detection and identification method be identified, a PFA declaration could be considered an effective phytosanitary measure.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination may be unlikely. Should an appropriate detection and identification method be identified, a PFPP declaration could be considered an effective phytosanitary measure.

Indexing of mother plants

Given that the aetiology of this apple disease is unknown, inspection for symptom expression is the only feasible option available. As disease symptoms are expressed on 2- to 3-year-old wood, woody indexing on the *Malus* cultivar 'Delicious' should be followed by inspections over a minimum of two growing seasons that include autumn and summer growing periods.

There is currently no information on the reliability of graft inoculation of Apple Transmissible Internal Bark Necrosis infected plants on to susceptible indicator plants, or the sensitivity of inspections for symptom expression. Assuming graft-inoculated indicator plants are inspected over a 3-year period for disease symptoms, indexing should be considered only a partially effective phytosanitary measure against Apple Transmissible Internal Bark Necrosis.

Inspection of mother plants

As Apple Transmissible Internal Bark Necrosis is considered latent in most commercial apple cultivars, inspection of mother plants would not be considered an effective phytosanitary measure unless those plants are known to be symptomatic of Apple Transmissible Internal Bark Necrosis (e.g. the *Malus* cultivar 'Delicious'). Assuming symptomatic mother plants are inspected over a 3-year period for disease symptoms, this measure should be considered only a partially effective phytosanitary measure against Apple Transmissible Internal Bark Necrosis.

8.22.4. References

All About Apples (2009) All about apples. Web based information available at http://www.allaboutapples.com/index.htm

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research,* June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

BA (2002) Review of Post-Entry Quarantine Protocols for the Importation in Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Biosecurity Australia; 68pp.

Jones, A L; Aldwinckle, H S (1990) Compendium of apple and pear diseases. American Phytopathological Society Press, St. Paul, Minnesota, USA; 100 pp.

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 3. Plant Diseases Division, DSIR, Auckland, New Zealand; 180pp.

PPIN (Year of search) Plant Information Network. MAF database.

WSU (2003) “Virus Free” Stone & Pome Fruit - Pome Fruit Diseases caused by Viruses (NRSP5) 2001. Washington State University. National Research Support Project 5. Supporting Research & Development. Pome Fruit-Virus Detection Procedures (NRSP5, Indexing Procedures) http://nrsp5.prosser.wsu.edu/index.html.

8.23. Quince yellow mosaic agent

8.23.1. Hazard identification

8.23.1.1. Aetiologic agent

Quince Yellow Mosaic is a disease of unknown aetiology.

8.23.1.2. New Zealand status

Quince Yellow Mosaic agent is not known to be present in New Zealand (Pearson *et al.* 2006, Pennycook 1989, PPIN 2009)

8.23.1.3. Biology and epidemiology

Quince Yellow Mosaic has been recorded as being absent from USA, Canada and Mexico (NAPPO 2004). There is only one record from India of Quince Yellow Mosaic disease associated with apple (Nagaich & Vashisth 1962). No further information was identified.

8.23.1.4. Hazard identification conclusion

Given the level of uncertainty around the legitimacy of Quince Yellow Mosaic disease association with *Malus,* and the absence of any substantial understanding of its biology or epidemiology, it is recommended that this disease of unknown aetiology not be considered a potential hazard in this risk analysis.

8.23.1.5. Assessment of uncertainty

Aside from the unknown aetiology, there is significant uncertainty around the biology, distribution and epidemiology of Quince Yellow Mosaic. As such this risk assessment should be reviewed once further relevant information becomes available

8.23.2. References

NAPPO (2004) Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and Xylella fastidiosa. NAPPO (North American Plant Protection Organisation) Regional Standards for Phytosanitary Measures (RSPM). RSPM No.25.

Nagaich, B B; Vashisth, K S (1962). On the occurrence of virus diseases of temperate fruits in India. *Indian Phytopath* 15(3-4): 222-224.

Pearson M N, Clover G R G, Guy P L, Fletcher J D, Beever R E (2006) A review of the plant virus, viroid and mollicute records for New Zealand. *Australasian Plant Pathology* 35; pp 217–252

Pennycook, S R (1989) *Plant diseases recorded in New Zealand.* Plant Diseases Division, DSIR; Auckland, New Zealand.

PPIN (Year of search) Plant Pest Information Network, MAF database.

9. Risk analyses - Bacteria

9.1. *Pseudomonas syringae* pv. *papulans*

9.1.1. Hazard identification

9.1.1.1. Aetiologic agent

Pseudomonas syringae pv. *papulans* (Rose 1917) Dhanvantari 1977, Zymobacteria, Pseudomonadales, Pseudomonadaceae.

9.1.1.2. New Zealand status

Pseudomonas syringae pv. *papulans* is not known to be present in New Zealand (NZFungi 2009, Pennycook 1989, PPIN 2009, Vanneste & Yu 2006)

9.1.1.3. Biology and epidemiology

A draft risk analysis on *Pseudomonas syringae* pv. *papulans* was completed in September 2002 by MAF Biosecurity Authority and concluded that the risk posed by this pathogen was negligible unless the cultivar 'Mutsu' was being imported. However, other cultivars, such as 'Fuji', 'Golden Delicious' and 'Gala', are susceptible when young leaves or fruit are inoculated with *P. syringae* pv. *papulans*. In Germany, severe damage to cultivar 'Delbarestivale' was reported in several orchards in the Stuttgart area. Therefore the host range of *P. syringae* pv. *papulans* appears to be larger than the single 'Mutsu' cultivar, even under field conditions (Kerkoud *et al*. 2002).

Strains

Burr *et al*. (1988) refer to 25-50 strains of *P. syringae* pv. *papulans* having been tested for resistance to streptomycin. Resistant strains were detected. Kerkoud *et al*. (2000) also list bacterial strains used in phenological, pathological, serological and molecular tests. Strains vary in their ability to cause mid-vein necrosis and other blister spot symptoms (Boon and Bedford 1986).

Biology and ecology

Pseudomonas syringae pv. *papulans* is a gram-negative, oxidase negative, aerobic, motile, rod-shaped bacterium. It is negative for levan production on sucrose medium, negative for liquefaction of gelatine and negative for ice-nucleation activity (Burr 1990).

The apple variety Mutsu was the only known overwintering host of this pathogen (Bedford *et al*. 1988). *P. syringae* pv. *papulans* survives in dormant buds, leaf scars and on diseased fruit on the orchard floor (Burr 1990; Burr and Katz 1982; Bedford 1980). Up to 60% of buds in an orchard may harbour the bacterium (Boom and Fisher 1989). The bacterium also survives as an epiphyte on leaves flowers, fruits and weeds in orchards (Burr 1990). High levels of inoculum are required for disease initiation and development (Burr and Hutwitz 1981). Artificial inoculation required 10^8 colony-forming units per millilitre of water (Burr and Hurwitz 1981).

Epidemiology

Rain in spring and summer spread the bacteria to leaves, blossoms and fruit surfaces where the bacteria multiply without causing symptoms (Jones and Sutton 1996; Boom and Fisher 1989). Insects are also implicated in the spread of inoculum (Boom and Fisher 1989). The fruit are susceptible to infection for approximately two to four weeks beginning approximately two weeks after petal fall (Bedford *et al*. 1988) and are infected through the stomata (Jones and Sutton 1996). As the fruit expand the stomata develop into lenticles which the bacteria cannot penetrate

(Boom and Fisher 1989) and so infection does not occur. Lesions appear on fruit 10-12 days after infection (Jones and Sutton 1996).

Warm, humid and wet conditions in spring and early summer favour the build-up of the bacterial population and the subsequent infection of leaf veins and fruit (Boom and Fisher 1989). The incidence of the disease is low in dry years (Burr 1990).

Symptoms

Midvein necrosis of ‘Mutsu’ apple leaves on spurs and shoots causes curled, puckered misshapen leaves and white to necrotic spots (Burr 1990). Wilting of the leaf margins and marginal leaf burn in ‘Mutsu’ are also reported (Bonn and Bedford 1986). Leaf symptoms are obvious before fruit symptoms (Burr 1990).

Superficial blemishes (> than 100 per fruit) make fruit unsuitable for sale as fresh produce. Infections are first visible two to three months after petal fall as small, green water-soaked raised blisters around the stomata on the fruit surface (Burr 1990). The blisters expand during the growing season and are approximately 1-5 mm in diameter, 1-2 mm deep with blistered brown centres and dark purple edges. The lesions are mostly rounded and shallow, and do not lead to fruit decay (Boom and Fisher 1989).

Other symptoms such as scruffy bark canker (Lacey and Dowson, 1931; Dhanvantari 1969) and twig infections (Dhanvantari 1969) have been attributed to this pathogen but not substantiated (Burr 1990).

Apple buds may be contaminated by the bacterium but appear healthy (Burr 1990). *P. syringae* pv. *papulans* has been isolated from buds of apple cultivars ‘Mutsu’, ‘Golden Delicious’ and ‘Empire’ (Burr and Katz 1984). Burr and Hurwitz (1981) reported the bacterium as an epiphyte on healthy leaves of ‘Golden Delicious’ trees. The bacterium is often present on tree parts, weeds and other foliage and no disease is present (Boom and Fisher 1989). Kerkoud *et al*. (2000) reported the presence of epiphytic populations of *P. syringae* pv. *papulans*, but no disease, in an orchard in France.

Host range

CAB International (2001) lists *Malus pumila*, *Prunus persica* and *Pyrus communis* as primary hosts of *P. syringae* pv. *papulans*. However, only references to varieties of *Malus* were found in the literature. Burr (1990) states that at least 25 cultivars of apple were reported susceptible to blister spot in the early literature but most are no longer of commercial importance. However, other cultivars, such as ‘Braeburn’, ‘Delicious’, ‘Fuji’, ‘Golden Delicious’, ‘Gala’ and ‘McIntosh’, are susceptible when young leaves or fruit is inoculated with *P. syringae* pv. *papulans* (Meresz *et al.* 1988, Sholberg & Bedford 1997). In Germany, sever damage to cultivar ‘Delbarestivale’ was reported in several orchards in the Stuttgart area (Kerkoud *et al*. 2002).

Geographical distribution

P. syringae pv. *papulans* recorded as being present in Italy (Bazzi and Calzolari 1983), France (Kerkoud *et al*. 2000), UK (Bradbury 1986), Germany (Kerkoud *et al*. 2002), Canada (British Columbia (Anon, undated) and Ontario (Boom and Fisher 1989), and USA (New York, Michigan, Arkansas, Illinois, Missouri, Pennsylvania (Bradbury 1986)) but absent from Australia (BA 2002).

9.1.1.4. Hazard identification conclusion

The accepted absence of *P. syringae* pv. *papulans* in New Zealand, the ability of this disease to be vectored by *Malus* nursery stock, and its potential to cause commercially important disease symptoms in New Zealand all suggest that *P. syringae* pv. *papulans* should be considered a potential hazard requiring further assessment.

9.1.2. Risk assessment

9.1.2.1. Entry assessment

The long distance spread of *P. syringae* pv. *papulans* is through the movement of infected nursery stock of susceptible cultivar. This bacterium is known to overwinter in the central tissues of dormant buds (Burr and Katz 1982) and leaf scars (Bedford 1980). Warm, humid or wet conditions in spring and early summer favour the build up of bacteria numbers and rain, irrigation and insects allows spread to leaves and fruit (Boom and Fisher 1989).

The presence of the bacterium in internal tissues poses a problem for detection at source and on arrival in New Zealand. The likelihood of survival of *P. syringae* pv. *papulans* in long-distance transport of infected propagation material is high as long as the propagated material remains viable.

It is therefore considered that the likelihood of entry of *P. syringae* pv. *papulans* into New Zealand with *Malus* nursery stock from infected populations is moderate to high and therefore non-negligible.

9.1.2.2. Assessment of exposure and establishment

Should *P. syringae* pv. *papulans* be associated with imported *Malus* nursery stock it would be expected to use the infested material as a vehicle to allow exposure and establishment in the New Zealand environment.

The likelihood of exposure and establishment should be considered high and therefore non-negligible.

9.1.2.3. Consequence assessment

Spread

Species of *Malus* are grown throughout New Zealand in home gardens and commercial orchards and can occur within roadside and wasteland sites. The major commercial pipfruit growing areas in New Zealand are in Hawkes Bay and Nelson. The disease occurs in Ontario and British Columbia in Canada and in New York, Michigan, Arkansas, Illinois, Missouri, and Pennsylvania in the USA where climatic conditions would be similar to those in New Zealand apple growing areas. Suitable conditions for bacterial multiplication and infection would occur in apple growing regions in most years.

The cultivar 'Mutsu' is present but only in very small numbers probably in home gardens or as part of enthusiast-growers' collections (White pers. comm. 2006). It is currently not grown commercially in New Zealand because it is very vigorous under our soil conditions and produces oversized fruit. It is not likely to be used in breeding programmes (White pers. comm. 2006). 'Fuji', which is highly susceptible when grown in close proximity to infected 'Mutsu' (Anon. undated), is grown widely and is an important commercial variety. The likelihood of spread after establishment is high in the presence of the cultivar 'Mutsu', however this apple cultivar is not common in New Zealand. Spread would occur on a local scale by rain splash, irrigation and insect dispersal (Boom & Fisher 1989) while over longer distances spread could occur via the movement of infected fruit and nursery stock. The likelihood of the spread of *P. syringae* pv. *papulans* is therefore considered moderate.

Economic consequences

To-date *P. syringae* pv. *papulans* has only been recorded causing significant economic disease on the cultivar 'Mutsu', and this cultivar is not grown widely and is not a commercial variety in New Zealand. The economic consequences to production are likely to be minor and mostly confined to nurseries or orchards where infected 'Mutsu' material was introduced unless the commercial varieties grown in New Zealand are susceptible to disease development. It is likely that a number of the newer varieties of commercial apple cultivars have never been exposed to this bacterium and as such their level of susceptibility is unknown. The economic impact to production in New Zealand could be significantly affected should a more widely grown commercial cultivar prove susceptible.

In Ontario in 1995 there was a minor outbreak of this disease in 'Fuji' grown in close proximity to 'Mutsu' and there was concern that the disease could spread to this and other susceptible cultivars (Anon. undated). If the disease occurred in 'Fuji' then the economic consequences would be more severe but would be limited by the removal of the inoculum source, the 'Mutsu' cultivar, as the pathogen does not overwinter on 'Fuji'.

Australia (potential market) and other existing markets for apples are currently considered to be free of *P. syringae* pv. *papulans* (BA 2002). There is a low likelihood that market access issues may result from the establishment and spread of *P. syringae* pv. *papulans* in New Zealand.

The potential economic impact of *P. syringae* pv. *papulans* on the New Zealand horticultural sector should therefore be considered to have a moderate likelihood of being low to moderate.

Environmental consequences

While there are no species of *Malus* native to New Zealand, the *Malus* genus is a member of the Rosaceae family which includes around two dozen native species in the genera *Rubus*, *Acena*, *Potenteilla* and *Geum* (Allan 1982). Symptoms of disease caused by *P. syringae* pv. *papulans*, namely localised fruit and leaf necrosis, while being of potential concern in commercial production are less likely to be of such significance in natural ecosystems. Naturalised introduced host species of the fruit trees in the urban environment might be affected by *P. syringae* pv. *papulans* lowering fruit yield or quality. These social impacts, while being significant on there own, are of less significance given the wide number of pests and diseases already associated with these hosts in New Zealand.

The potential environmental impact of *P. syringae* pv. *papulans* in New Zealand should therefore be considered to have a low likelihood of being low.

Human health consequences

P. syringae pv. *papulans* is not known to be of any significance to human health.

9.1.2.4. Conclusion of consequence assessment

From the assessment above it is concluded that *P. syringae* pv. *papulans* has a moderate likelihood of causing low to moderate economic consequences and low likelihood of causing low environmental consequences to New Zealand.

9.1.2.5. Risk estimation

The likelihood estimate is high that *P. syringae* pv. *papulans* would be associated with *Malus* nursery stock on entry into New Zealand, high that any *P. syringae* pv. *papulans* that does enter would successfully establish in New Zealand, moderate that the establishment would result in low to moderate economic consequences, and low that the establishment would result in low environmental consequences to New Zealand. As a result the risk estimate for *P. syringae* pv.

papulans associated with imported *Malus* nursery stock is non-negligible and should be considered a hazard.

9.1.2.6. Assessment of uncertainty

There is some uncertainty around the biology, distribution and epidemiology of *P. syringae* pv. *papulans*. As such this risk assessment should be reviewed once further relevant information becomes available.

9.1.3. Risk management

9.1.3.1. Risk evaluation

Since the risk estimate for *P. syringae* pv. *papulans* associated with imported *Malus* nursery stock is non-negligible, options for phytosanitary measures are provided for consideration.

9.1.3.2. Option evaluation

There are conceivably a number of management options available for *P. syringae* pv. *papulans* on imported *Malus* nursery stock. The following risk management options are assessed:

a. Pest free area (PFA) (see section 4.3.7 for background): *Malus* nursery stock is imported from areas that they are free of *P. syringae* pv. *papulans*;

b. Pest free place of production (PFPP) (see section 4.3.7 for background): *Malus* nursery stock is imported from a place of production that is free of *P. syringae* pv. *papulans*;

c. Testing (indexing) of mother plants either prior to export to New Zealand or on arrival in New Zealand in a post entry quarantine facility;

d. Treatment of *P. syringae* pv. *papulans* by a suitably efficacious method.

Pest free area (PFA)

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. Visual examination may reveal infected plants in the field, but the absence of symptoms does not exclude latent infection. Vanneste & Yu (2006) developed a protocol to specifically detect *P. syringae* pv. *papulans* in apple buds in New Zealand. The protocol is based on the amplification by polymerase chain reaction (PCR) of part of the *hrp*L gene. Using this protocol, presence of *P. syringae* pv. *papulans* could be routinely detected in apple buds spiked with 100 cells of the pathogen. This protocol was used to analyse budwoods from Hawke's Bay and Waikato and apple fruit from Waikato, Hawke's Bay and Central Otago (Vanneste & Yu 2006). Based on the sensitivity and specificity of the PCR test, a suitable sampling and survey protocol would need to be developed to ensure an effective PFA could be established.

Pest free place of production (PFPP)

As with PFA above, it should be considered that a reliable PFPP determination based on an appropriate detection and sampling protocol could be considered an effective phytosanitary measure.

Indexing of mother plants

Earliest spots are usually detected near the calyx end of fruit that face the sun and are on the periphery of the tree (Boom and Fisher 1989). As disease symptoms are dependent on climatic conditions and cultivar type, indexing should occur on symptomatic cultivars (e.g. 'Mutsu') and inspections should occur over a minimum of two growing seasons that include spring, summer and autumn growing periods.

In the laboratory the bacteria can be isolated from fruit using King's B medium (Burr 1990) and can be cultured and maintained on yeast dextrose carbonate agar (Bedford *et al*. 1988). Material imported *in vitro* could be sampled and tested on this medium for contamination. Physical and biochemical tests are described by Dhanvantari (1977). Diagnosis by Polymerase Chain Reaction (PCR) using specifically designed *hrpL* gene primers was described by Kerkoud *et al*. (2002) for use on diseased fruit and artificially inoculated leaves. Vanneste & Yu (2006) developed a PCR test for use in surveys in New Zealand.

There is currently no information on the reliability of inoculation of *P. syringae* pv. *papulans* infected plants on to susceptible indicator plants or the sensitivity of inspections for symptom expression. Vanneste & Yu (2006) reported that their PCR protocol detected 15 tested strains of *P. syringae* pv. *papulans* from inoculations of 100 bacteria or more. The same PCR protocol did not detect *P. syringae* pv. *tomato*, *P. fluorescens*, a species of *Pseudomonas*, or *Erwinia amylovora* (Vanneste & Yu 2006). Assuming inoculation is performed under optimal conditions for infection and indicator plants are inspected over a 2-year period for disease symptoms, indexing should be considered an effective phytosanitary measure against *P. syringae* pv. *papulans*. Direct PCR testing of bud material, sampled after a period of optimal conditions for *P. syringae* pv. *papulans* epiphyte development and using the protocol developed by Vanneste & Yu (2006), should also be considered an effective method of detecting *P. syringae* pv. *papulans* infestations.

Treatments

The highest populations of bacteria are found in the centre of buds and are not susceptible to sprays (Boom and Fisher 1989). Currently there are no treatments known that have supporting information to provide an adequate confidence of achieving a suitable level of efficacy against *P. syringae* pv. *papulans*. Some strains of *P. syringae* pv. *papulans* are known to be resistant to streptomycin (Burr *et al*. 1988). Should an appropriate treatment method be identified and suitably supported, a treatment declaration could be considered an effective phytosanitary measure.

9.1.4. References

Allan H H (1982) Flora of New Zealand. Volume 1. Indigenous Tracheophyta - Psilopsida, Lycopsida, Filicopsida, Gymnospermae, Dicotyledons. *First electronic edition, Landcare Research*, June 2004. Transcr. A. D. Wilton and I. M. L. Andres. http://FloraSeries.LandcareResearch.co.nz. Accessed 25 March 2009

Anon. undated. Blister Spot. Ministry of Agriculture, Food and Fisheries, British Columbia, Canada.

Bazzi, C; Calzolari, A (1983) Bacterial blister spot of 'Mutsu' apples in Italy. *Phytopathology Mediterranean* 22: 19-21.

Bedford, K E (1980) Survival of a marker strain of *Pseudomonas syringae* pv. *papulans* in apple leafscars. *In*: *Proceedings of the Northeastern Division Meeting of the American Phytopathological Society*, p17.

Bedford, K E; MacNeill, B H; Bonn, W G; Dirks, V A (1988) Population dynamics of *Pseudomonas syringae* pv. *papulans* on Mutsu apples. *Canadian Journal of Plant* Pathology 10: 23-29.Boom, W.G. and Fisher, P. 1989. Blister Spot of Apples. Factsheet, Ontario Ministry of Agriculture and Food.

Bonn, W G; Bedford, K E (1986) Midvein necrosis of Mutsu apple leaves caused by *Pseudomonas syringae* pv. *papulans*. Canadian Journal of Plant Pathology 8: 167-169.

Bradbury, J F (1986) Guide to plant pathogenic bacteria. CAB International, Wallingford, Oxon OX10 8DE, UK.

Burr, T J; Hurwitz, B (1981) Seasonal susceptibility of Mutsu apples to *Pseudomonas syringae* pv. *papulans*. *Plant Disease* 65: 334-336.

Burr, T J; Katz, B (1982) Evaluation of a selective medium for detecting *Pseudomonas syringae* pv. *papulans* and *P. syringae* pv. *syringae* in apple orchards. *Phytopathology* 72: 564-567.

Burr, T J; Katz, B (1984) Overwintering and distribution pattern of *Pseudomonas syringae* pv. *papulans* in apple orchards. *Plant Disease* 68: 383-385.

Burr, T J; Norelli, J L; Katz, B; Wilcox, W; Hoying, S A (1988) Strepomycin resistance of *Pseudomonas syringae* pv. *papulans* in apple orchards and its association with a conjugative plasmid. *Phytopathology* 78: 410-413.

Burr, T J (1990) Blister Spot. *In*: Jones, A. L. and Aldwinckle, H. S. [Eds.]. *Compendium of Apple and Pear Diseases*. APS Press, St Paul, Minnesota. 100 pp.

CAB International (2001) *Crop Protection Compendium*, 2nd Edition, CAB International, Wallingford, Oxon OX10 8DE, UK.

Dhanvantari, B N (1969) Bacterial blister spot of apple in Ontario. *Canadian Plant Disease Survey* 49: 36-37.

Dhanvantari, B N (1977) A taxonomic study of *Pseudomonas papulans* Rose 1917. *New Zealand Journal of Science* 11: 590-607.

Jones, A L; Sutton, T B (1996) *Diseases of Tree fruits in the East*. Michigan State University Extension, USA.

Kerkoud, M; Manceau, C; Gardan, L; Samson, R; Paulin, J-P (2000) Epiphytic occurrence of *Pseudomonas syringae* pv. *papulans* (Rose) in France, where blister spot has ever been seen. *European Journal of Plant Pathology* 106 (5): 481-485.

Kerkoud, M; Manceau, C; Paulin, J P (2002) Rapid diagnosis of *Pseudomonas syringae* pv. *papulans*, the causal agent of blister spot of apple, by Polymerase Chain Reaction using specifically designed *hrpL* gene primers. *Bacteriology* 92(10): 1077-1083.

Lacey, M; Dowson, W J (1931) Studies in bacteriosis. XVIII. A bacterial canker of apple trees. *Annals of Applied Biology* 18: 30-36.

MAF Biosecurity (September 2002) *Pest risk assessment Pseudomonas syringae pv. papulans (blister spot).* MAF Biosecurity Authority; Wellington New Zealand.

Meresz A, Fisher P, Thorpe C (1988) Disease survey of commercial apple orchards in southern Ontario. *Canadian Plant Disease Survey* 68, pp 169-171

NZFungi (Year of search) New Zealand fungi (and bacteria). Landcare Research New Zealand Limited. Available on line at http://nzfungi.landcareresearch.co.nz/html/mycology.asp

Parker, K G; Burkholder, W H (1950) *Pseudomonas syringae* van Hall on apple and pear in New York State. *Plant Disease Reporter* 34: 100-101.

Pennycook, S R (1989) *Plant diseases recorded in New Zealand.* Plant Diseases Division, DSIR; Auckland, New Zealand.

PPIN (Year of search) Plant Information Network. MAF database.

Sholberg P L, Bedford K E (1997) Characterization of blister spot (*Pseudomonas syringae* pv. *papulans*) in British Columbia and its potential for spread to new apple cultivars. *Canadian Journal of Plant Pathology* 19, pp 347-351.

Vanneste J L, Yu J (2006) Detection of *Pseudomonas syringae* pv. *papulans* in apple budwood. *New Zealand Plant Protection* 59, pp 146-149.

Walker, G (2005) "Blister Spot" in Publication 360, Fruit Production Recommendations: Apples (2007); http://www.omafra.gov.on.ca/english/crops/facts/blistersp.htm

White A pers. comm. (2006) Business Leader, *Plant and Food Research*, Havelock North, New Zealand.

Glossary of Terms

Area	An officially defined country, part of a country or all or part of several countries, as identified by the competent authorities (SPS Agreement 1994)
Biosecurity	The exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health (Biosecurity Strategy 2003)
Biosecurity clearance	A clearance under section 26 of this Act for the entry of goods into New Zealand (Biosecurity Act 1993)
Budding	Which is really bud grafting, is essentially the use of a single bud (the scion) plus a portion of rind with or without a sliver of wood that is sited on the rootstock between two flaps of rind (e.g. T-budding), replaces a section of rind (patch budding), or replaces a pre-cut veneer of rind and woody tissue (chip budding) (Macdonald 1986).
Commodity	A good being moved for trade or other purposes. Packaging, containers, and craft used to facilitate transport of commodities are excluded unless they are the intended good.
Consequences	The adverse effects or harm as a result of entry and establishment of a hazard, which cause the quality of human health or the environment to be impaired in the short or longer term.
Disease	A finite abnormality of structure or function with an identifiable pathological or clinicopathological basis, and with a recognizable syndrome of clinical signs. Its cause may not be known, or may be from infection with a known organism (Blood & Studdert 1990)
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (CBD 1992)
Entry (of a organism or disease)	Movement of an organism or disease into a risk analysis area.
Environment	(Biosecurity Act 1993) Includes: (a) Ecosystems and their constituent parts, including people and their communities; and (b) All natural and physical resources; and (c) Amenity values; and (d) The aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to in paragraphs (a) to (c) of this definition
Establishment	Perpetuation, for the foreseeable future, of an organism or disease within an area after entry
Exposure	The condition of being vulnerable to adverse effects
FAO	Food and Agriculture Organization, United Nations.
Grafting	A technique used to unite “parts” of different plants by bringing the cambium of each into contact and then creating a situation under which the cut surfaces can unite and grow away together
Growing season	An extended period of plant growth that includes environmental conditions equivalent to spring (longer wetter days and cold temperatures), summer (longer dryer days and warm temperatures), and autumn (shorter wetter days and warm but cooling temperatures)
Hazard organism	Any disease or organism that has the potential to produce adverse consequences

HEPA filter	A 'high-efficiency particulate air' (HEPA) Type 1, Class A filter as specified in AS 1324.1 with metal separators and elastomeric compression seals, which meets all requirements of AS 4260 with a minimum performance of Grade 2 and complies with US Military Specification MIL-F-51079-D or an equivalent specification (AS/NZS 2243.3 2002).
Hitchhiker organism	An organism that is carried by or with a commodity and is not a pest of the commodity.
Import health standard (IHS)	A document issued under section 22 of the Biosecurity Act 1993 by the Director General of MAF, specifying the requirements to be met for the effective management of risks associated with the importation of risk goods before those goods may be imported, moved from a biosecurity control area or a transitional facility, or given a biosecurity clearance Note: An import health standard is also an "import permit" as defined under the IPPC
Import risk analysis	A process to identify appropriate risk mitigating options for the development of import health standards. These risk analyses can focus on an organism or disease, a good or commodity, a pathway, or a method or mode of conveyance such as shipping, passengers or packaging.
Inspector	Person authorized by a National Plant Protection Organization to discharge its functions (FAO 2009)
IPPC	International Plant Protection Convention (1997), FAO
MAF	New Zealand Ministry of Agriculture and Forestry
Measure	A measure may include all relevant laws, decrees, regulations, requirements and procedures including, *inter alia*, end product criteria; processes and production methods; testing, inspection, certification and approval procedures; quarantine treatments including relevant requirements associated with the transport of risk goods, or with the materials necessary for their survival during transport; provisions on relevant statistical methods, sampling procedures and methods of risk assessment; and packaging and labelling requirements directly related to biosecurity
Micro-organism	A protozoan, fungus, bacterium, virus or other microscopic self-replicating biotic entity (FAO 2009)
Nursery stock	Whole plants or parts of plants imported for growing purposes, e.g. cuttings, scions, budwood, marcots, off-shoots, root divisions, bulbs, corms, tubers and rhizomes
Open-ground budding/bud grafting	A method of grafting, normally done in summer, in which a single bud with rind (with or without a sliver of wood) is placed within the rootstock
Open-ground (field) grafting	A multi-budded dormant scion is grafted onto an established open-ground rootstock.
Organism	(Biosecurity Act 1993) (a) Does not include a human being or a genetic structure derived from a human being: (b) Includes a micro-organism: (c) Subject to paragraph (a) of this definition, includes a genetic structure that is capable of replicating itself (whether that structure comprises all or only part of an entity, and whether it comprises all or only part of the total genetic structure of an entity): (d) Includes an entity (other than a human being) declared by the Governor-General by Order in Council to be an organism for the purposes of this Act: (e) Includes a reproductive cell or developmental stage of an organism: (f) Includes any particle that is a prion.
Pathway	Any means that allows the entry or spread of a potential hazard

Pest	Any species, strain or biotype of plant, animal or pathogenic agent, injurious to plants or animals (or their products) or human health or the environment. Note: the definition given for "pest" here is different from that used in the Biosecurity Act 1993 "an organism specified as a pest in a pest management strategy". The Biosecurity Act 1993 deals more with "risks" and "risk goods".
Pest risk assessment	A process to measure the level and nature of biosecurity risk posed by an organism. A pest risk assessment can be used to inform biosecurity surveillance activities or identify pests of high risk to New Zealand.
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2009).
Plants *in vitro*	A commodity class for plants growing in an aseptic medium in a closed container (FAO 2009; formerly plants in tissue culture)
Post-entry quarantine (PEQ)	Quarantine applied to a consignment after entry (FAO 2009)
Residual risk	The risk remaining after risk management requirements have been implemented.
Risk	The likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.
Risk analysis	The process composed of hazard identification, risk assessment, risk management and risk communication.
Risk analysis area	The area in relation to which a risk analysis is conducted.
Risk assessment	The evaluation of the likelihood, and the biological and economic consequences, of entry, establishment, or exposure of an organism or disease.
Risk good	(Biosecurity Act 1993) Means any organism, organic material, or other thing, or substance, that (by reason of its nature, origin, or other relevant factors) it is reasonable to suspect constitutes, harbours, or contains an organism that may: (a) Cause unwanted harm to natural and physical resources or human health in New Zealand; or (b) Interfere with the diagnosis, management, or treatment, in New Zealand, of pests or unwanted organisms
Risk management	The process of identifying, selecting and implementing measures that can be applied to reduce the level of risk.
Root-less cuttings	Plant cuttings that may have leaves and shoots, but no roots.
Scion	The part of the graft that will provide the new shoot system. The scion may be united ether at the apex or side of the rootstock.
Spread	Expansion of the geographical distribution of a potential hazard within an area.
SPS Agreement 1995	World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (1995).
Tissue culture	See "Plants *in-vitro*"
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2009)

Unwanted organism	(Biosecurity Act 1993) Means any organism that a chief technical officer believes is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health; and (a) Includes: (i) Any new organism if the Authority has declined approval to import that organism; and (ii) Any organism specified in the Second Schedule of the Hazardous Substances and New Organisms Act 1996; but (b) Does not include any organism approved for importation under the Hazardous Substances and New Organisms Act 1996, unless: (i) The organism is an organism which has escaped from a containment facility; or (ii) A chief technical officer, after consulting the Authority and taking into account any comments made by the Authority concerning the organism, believes that the organism is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health.
Whole plants	A nursery stock commodity sub-class for rooted cuttings and plants with roots and leaves

References for glossary of terms

AS/NZS 2243.3 (2002) Safety in laboratories - Microbiological aspects and containment facilities. Australian/New Zealand Standard. Standards Australia/Standards New Zealand. pp. 1-8; Available at http://www.saiglobal.com/shop/script/search.asp

Biosecurity Act (1993) An Act to restate and reform the law relating to the exclusion, eradication, and effective management of pests and unwanted organisms. *New Zealand Legislation*. http://www.legislation.govt.nz/act/public/1993/0095/latest/DLM314623.html

Biosecurity Strategy (2003) The Biosecurity Strategy for New Zealand. *New Zealand Ministry of Agriculture and Forestry*. Available at http://www.biosecurity.govt.nz/bio-strategy/

Blood D C, Studdert V P (1990) Bailliere's Comprehensive Veterinary Dictionary. *Bailliere Tindall*. P 458.

CBD (1992) The Convention on Biological Diversity. UNEP. Available online at www.cbd.int/convention/articles.asp

FAO (2009) ISPM No. 5 Glossary of phytosanitary terms. Available at: https://www.ippc.int/IPP/En/default.jsp

Macdonald B (1986) Practical Woody Plant Propagation for Nursery Growers: Volume 1. *Timber Press*, 660 pages.

SPS Agreement (1994) Agreement on the Application of Sanitary and Phytosanitary Measures. *World Trade Organization*, Geneva. Available at http://www.wto.org/

Appendix 1 Potential hazards – descriptions and references

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Viruses				
Apple chlorotic leaf spot virus	apple chlorotic leafspot trichovirus, apricot butteratura, apricot incompatibility and decline, apricot pseudo pox, apricot viruela, peach dark sunken mottle, plum pseudo pox, prune bark split (CPC 2007) ACLSV (NAPPO 2004)	apple chlorotic leaf spot trichovirus, bark split virus, apple latent Type1 virus, apple latent virus type 1 (NAPPO 2004), pear ring pattern mosaic virus (NAPPO 2004), plum pseudopox virus?, Quince stunt virus (NAPPO 2004), pear ring mosaic virus (NAPPO 2004), pear mosaic virus?, platycarpa line pattern virus (NAPPO 2004), Quince leafspot virus (NAPPO 2004). freckle scurf?; pear ring pattern mosaic virus (Cropley, 1969), plum pseudopox virus, quince stunt virus (Brunt et al. 1996) plum bark split virus, apple latent 1 virus, pear ring pattern mosaic virus (CPC 2007)	Pearson *et al.* 2006, Pennycook 1989, Jones & Aldwinckle 1990, Grove et al. 2003, BA 2002, WSU 2003, CPC 2007, NAPPO 2004, Brunt *et al*. 1996	Yes (PPIN 2009; Pearson *et al.* 2006)
Apple latent spherical virus			NAPPO 2004, Fauquet *et al* 2005	No (Pearson *et al.* 2006, PPIN Nov05)
Apple mosaic virus	apple mosaic virus, European plum line pattern virus, chestnut mosaic, peach line patter, rose mosaic, apple infectious variegation virus, plum line pattern virus, rose infectious chlorosis virus (CPC 2007)	apple infectious variegation virus B.& J., Mc Intosh leaf pucker?, European plum line pattern virus, Hop virus A, rose infectious chlorosis virus, Rose mosaic virus, Shiroplum line pattern virus (NAPPO 2004), Apple mosaic ilavirus, Mountain ash variegation virus, Birch line pattern virus, Birch ringspot virus, Dutch plum line pattern virus, Horsechestnut yellow mosaic virus, Hop A virus, Hop virus C, mild apple mosaic virus, severe apple mosaic virus (CPC 2007), Prunus necrotic ringspot virus (Pearson et al 2006)	Pearson *et al.* 2006, Pennycook 1989, NAPPO 2004, Wood 1996, Dingley 1969, Grove et al. 2005, WSU 2003, CPC 2007, Brunt et al. 1996	Yes (Pearson *et al.* 2006)
Apple stem grooving virus	ASGV	Apple stem grooving virus, apple topworking disease, Citrange stunt virus, Citrus tatter leaf virus, Virginia crab apple decline, Apple latent virus Type 2, Apple brown line virus , Chenopodium dark green epinasty virus, Apple dark green epinasty virus, E36 virus, Virginia crab stem grooving virus, Apple brown line virus (CPC 2007) apple brown line virus, apple latent virus Type 2, darkgreen epinasty virus in C. quinoa, E 36 virus, Virginia crab stem grooving virus (NAPPO 2004)	Pearson *et al.* 2006, Pennycook 1989, Wood 1979, Jones & Aldwinckle 1990, CPC 2007, Grove et al. 2003, WSU 2003, NAPPO 2004, Brunt et al. 1996	Yes (Pearson *et al.* 2006, PPIN 2009, CPC 2007)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Apple stem pitting virus	ASPV	Apple Spy 227 epinasty and decline agent, Apple Spy 227 lethal virus, Apple Spy decline virus, Pear necrotic spot virus, Pear vein yellows and red mottle agent, Quince sooty ringspot virus (NAPPO 2004). apple spy epinasty & decline virus? Pear yellows virus, hawthorn ring pattern mosaic virus, pear stony pit virus - Brunt et al. 1996; pear red mottle (CPC 2007), Quince fruit deformation (Paunovic & Rankovic 1997).	Pearson *et al.* 2006, Pennycook 1989, NAPPO 2004, CPC 2007, Grove et al. 2003, WSU 2003, Brunt et al. 1996	Yes (Pearson *et al.* 2006, CPC 2007)
Carnation ringspot virus [strains N, A and R]	CRSV	Anjermozaick virus (Brunt *et al*. 1996 - this is a Netherland term), carnation ringspot dianthovirus (CPC 2007).	CPC 2007, NAPPO 2004	Yes (Pearson *et al.* 2006 - virus on *Dianthus* sp. only)
Cherry rasp leaf virus	cherry rasp leaf virus, rasp leaf of cherry, flat apple, CRLV	apple flat apple virus (NAPPO 2004), Flat apple virus; cherry rasp leaf nepovirus (BA 2002).	CPC 2007, BA 2002, NAPPO 2004, Brunt *et al*. 1996, WSU 2003	No. Listed as recorded on *Prunus avium* in Pennycook 1989; Pearson *et al.* 2006 reviewed the status but found no supporting evidence to confirm its presence.
Clover yellow mosaic virus		pea mottle virus (Brunt et al. 1996)?	CPC 2007, Brunt *et al*. 1996	No (Pearson *et al.* 2006; PPIN Dec 06)
Horseradish latent virus	HRLV		Brunt *et al*. 1996	No (PPIN 2009; Pearson *et al.* 2006; Brunt *et al*. 1996)
Prunus necrotic ringspot virus	PNRSV, almond bud failure, almond calico, almond line pattern, almond necrotic ringspot, apricot line pattern, apricot necrotic ringspot, cherry lace leaf, cherry necrotic ringspot, cherry ringspot, cherry rugose mosaic, cherry tatter leaf, peach mule's ear, peach necrotic leafspot, peach necrotic ringspot, peach willow leaf, plum decline, plum oak leaf, peach ringspot, sour cherry fruit necrosis, sour cherry line mosaic, cherry stecklenberger disease, sour cherry necrotic ringspot, cherry (sour) necrotic ringspot virus, cherry line pattern, necrotic ringspot virus (CPC 2007)	European plum line pattern virus, hop B virus, hop C virus, peach ringspot virus, plum line pattern virus, prunus ringspot virus, red currant necrotic ringspot virus, rose chlorotic mottle virus, rose line pattern virus, rose vein banding virus, rose yellow vein mosaic virus, sour cherry necrotic ringspot virus, cherry line pattern virus, North American plum line pattern virus, cherry rugose mosaic virus, Danish plum line pattern virus (CPC 2007)	CPC 2007, Brunt *et al.* 1996. Not recorded as being associated with *Malus* species by ICTVdB (2006). Host association not likely to be significant.	Yes (Pearson *et al.* 2006; PPIN 2009; CPC 2007) widespread but not confirmed on *Malus* species.
Sowbane mosaic virus	SoMV	Apple latent virus 2, Chenopodium mosaic virus, Chenopodium star mottle virus, chenopodium seed-borne mosaic virus, sowbane mosaic sobemovirus, (CPC 2007)	WSU 2003, NAPPO 2004, Brunt et al. 1996	No (Pearson *et al.* 2006; PPIN 2009)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Tobacco mosaic virus	tobacco mosaic, TMV; marmor tabaci, TMV U1, TMV-type, TMV-vulgare o common strain (CPC 2007)	has many synonyms and strains - Brunt et al. 1996; tobacco mosaic tobamovirus, VMT, TMV U1 type vulgare or common strain, (CPC 2007), tobacco mosaic virus - Rakkyo strain (Fauquet *et al* 2005)	CPC 2007, WSU 2003, NAPPO 2004. Not recorded as being associated with *Malus* species by ICTVdB (2006). Host association not likely to be significant.	Yes (Pearson *et al.* 2006; PPIN) widespread but not confirmed on *Malus* species.
Tobacco necrosis virus (Tobacco necrosis virus A, Tobacco necrosis virus D)	TNV-A and TNV-D respectively	Bean stipple streak virus, tobacco necrosis necrovirus, Chenopodium necrosis necrovirus, cucumber systemic necrosis virus, Euonymus mosaic virus, strawberry necrotic rosette virus, tulip Augusta disease virus, tulip necrosis virus (CPC 2007)	CPC 2007, NAPPO 2004, WSU 2003. Not recorded as being associated with *Malus* species by ICTVdB (2006). Host association not likely to be significant.	Yes (Pearson *et al.* 2006) widespread but not confirmed on *Malus* species.
Tobacco ringspot virus	TRSV	anemone necrosis virus, tobacco ringspot virus No. 1, nicotiana virus 12, blueberry necrotic ringspot virus, soybean bud blight virus, tobacco Brazilian streak virus (CPC 2007)	NAPPO 2004. Not recorded as being associated with *Malus* species by ICTVdB (2006) or EPPO (1999). Host association not likely to be significant.	Yes (Pearson *et al.* 2006) widespread but not confirmed on *Malus* species.
Tomato bushy stunt virus	TBSV, tomato bushy stunt virus	Lycopersicon virus 4	CPC 2007, BA 2002, WSU 2003, Brunt *et al*. 1996	No (Pearson *et al.* 2006; PPIN Aug 2004)
Tomato ringspot virus (Grape yellow vein strain)			NAPPO 2004, BA 2002; Jones & Aldwinckle 1990, Pennycook 1989, CPC 2007, Nemeth *et al*.1986; Brunt *et al*. 1996, WSU 2003	Yes (Pearson *et al.* 2006) widespread but not confirmed on *Malus* species.

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Tomato ringspot virus (except Grape yellow vein strain)	Ringspot of tomato, ToRSV, ringspot of tomato, yellow bud mosaic of peach, yellow vein of grapevine, redcurrant chlorosis mosaic, chlorosis of pelargonium, apple union necrosis, peach yellow bud mosaic, yellow blotch curl of raspberry, prunus stem pitting, grapevine yellow vein, American currant mosaic, brownline disease of prune, decline in red raspberry, Himalaya blackberry mosaic, ringspot disease of raspberry, stem pitting of peach (CPC 2007)	Blackberry (Himalaya) mosaic virus, euonymus ringspot virus, grapevine yellow vein virus, prune brown line virus, prunus stem-pitting virus, red currant mosaic virus, tobacco ringspot virus 2, winter peach mosaic virus, euonymus chlorotic ringspot virus, Nicotiana 13 virus, tomato ringspot nepovirus, peach stem pitting virus, apple union necrosis nepovirus (CPC 2007), peach yellow bud mosaic virus (Cadman and Lister, 1961; Thomas and Rawlins, 1950)	BA 2002, CPC 2007, NAPPO 2004, Brunt *et al*. 1996	No (Pearson *et al.* 2006)
Tulare apple mosaic virus	TAMV	Apple mosaic (Tulare) virus	Jones & Aldwinckle 1990, CPC 2007, NAPPO 2004, Brunt *et al*. 1996, Grove *et al* 2003	No (PPIN 2009; Pearson *et al.* 2006)
Viroids				
Apple dimple fruit viroid	ADFVd, apple dimple fruit		CPC 2007, NAPPO 2004, Grove et al. 2003, BA 2002, WSU 2003	No (PPIN 2009, CPC 2007, Pearson *et al.* 2006)
Apple fruit crinkle viroid		apple fruit crinkle, apple blister bark, Japanese pear fruit dimple (Biosecurity Authority 2002). apple fruit wrinkle?, Apple blister bark (Delicious) (WSU 2003)	BA 2002, WSU 2003, NAPPO 2004	No (PPIN 2009, Pearson *et al.* 2006)
Apple scar skin viroid	apple scar skin, dapple apple, pear rusty skin; apple dimple, apple ring blotch, Japanese pear fruit dimple, pear fruit crinkle (CPC 2007)	Dapple apple apscaviriod (NAPPO 2004). Apple dapple apple viroid, dapple apple viroid. Apple sabi-ka? Dapple apple virus, Apple 'sabi-ka' virus (CPC 2007)	Jones & Aldwinckle 1990, Hadidi *et al*. 1991, Grove et al. 2003, BA 2002, NAPPO 2004, WSU 2003, CPC 2007	No (PPIN 2009; Pearson *et al.* 2006)
Peach latent mosaic viroid	PLMVd, American mosaic of peach, peach yellow mosaic, peach latent mosaic disease, American peach mosaic, peach blotch (CPC 2007)	peach blotch, peach latent mosaic virus, peach yellow mosaic, peach yellow mosaic viroid, Prunus virus 5, Peach virus 6, Peach American mosaic disease, Peach American mosaic pathogen, Peach calico (teleomorph), Peach mosaic (teleomorph) (CPC 2007), peach latent mosaic viroid - apple strain (Fauquet 2005)	CPC 2007	No (PPIN 2009; Pearson *et al.* 2006; CPC 2007)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Phytoplasma				
Candidatus Phytoplasma asteris	Apple sessile leaf		Jomantiene & Davis 2005	No (PPIN 2009, Pearson *et al.* 2006; Pennycook 1989)
Candidatus Phytoplasma mali	apple proliferation, AT, AP	Candidatus Phytoplasma mali (Seemüller & Schneider), 2004. Apple proliferation phytoplasma, Phytoplasma mali (Candidatus) (CPC 2007). Apple proliferation virus, apple witches' broom virus (NAPPO 2004)	Jones & Aldwinckle 1990, NAPPO 2004, CPC 2007, Grove et al. 2003, BA 2002, WSU 2003	No (CPC 2007; Pearson *et al.* 2006; Pennycook 1989; PPIN 2009)
Candidatus Phytoplasma pyri	pear decline	[Candidatus Phytoplasma pyri (Seemüller & Schneider, 2004; Pear decline phytoplasma (CPC 2007)	CPC 2007, WSU 2003, NAPPO 2004	No (PPIN 2009; Pearson *et al.* 2006; Pennycook 1989)
Diseases of unknown aetiology				
Apple blister bark agent		alligator bark, blister bark, blister bark 1, blister bark 2, blister bark 3, scaly bark (BA 2002)	NAPPO 2004, BA 2002, WSU 2003; Jones & Aldwinckle 1990	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple brown ringspot agent			BA 2002, WSU 2003, NAPPO 2004, Nemeth 1986	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple bumpy fruit agent		Apply bumpy fruit of Ben Davis agent, apple bumpy fruit (Ben Davis), apple bumpy fruit (India).	WSU 2003, BA 2002, NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple bunchy top agent			NAPPO 2004, BA 2002, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple chat fruit agent	apple chat fruit	apple small fruit (NAPPO 2004, Pennycook 1989), chat fruit of apple (CPC 2007)	Jones & Aldwinckle 1990, NAPPO 2004, Pennycook 1989, CPC 2007, Grove et al. 2003, BA 2002, WSU 2003	Yes (Pearson *et al.* 2006; CPC 2007)
Apple dead spur agent		Pink phloem, Spur Death, Blind wood (WSU 2003)	Jones & Aldwinckle 1990, NAPPO 2004, Grove et al. 2003, BA 2002, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple decline agent		Apple decline (2) & apple decline phytoplasma, apple decline MLO & apple decline mycoplasma. apple false sting virus?	Jones & Aldwinckle 1990, NAPPO 2004, Grove et al. 2003, WSU 2003, BA 2002	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Apple flat limb agent	apple flat limb		Pennycook 1989, NAPPO 2004, WSU 2003, BA 2002	Yes (Pearson *et al.* 2006)
Apple freckle scurf agent	apple freckle scurf		Jones & Aldwinckle 1990, BA 2002, WSU 2003, NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple green crinkle agent	false sting, dimple (PPIN 2009)	apple false sting virus, apple false sting (NAPPO); apple green crinkle virus (CPC 2007)	Grove et al. 2003, Pennycook 1989, Wood 1979, BA 2002, WSU 2003, NAPPO 2004, CPC 2007	Yes (PPIN 2009; Pearson *et al.* 2006)
Apple green dimple and ring blotch agent		apple green mottle agent (NAPPO 2004)	NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple junction necrotic pitting agent			BA 2002, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple leaf chlorosis and fruit distortion agent			Wood 2001	Yes (Pearson *et al.* 2006; Wood 2001)
Apple leaf fleck, bark blister, and fruit distortion agent	apple leaf, fleck, bark blister, fruit russet & distortion	may be apple russet ring. Bark blister, fruit russet and distortion (Granny Smith) (BA 2002)	Pennycook 1989, BA 2002, WSU 2003, Wood, 1972; Wood, 1979	Yes (Pearson *et al.* 2006; Wood, 1972; Wood, 1979)
Apple leaf pucker and fruit russet agent		Apple leaf pucker virus & related disorders. May be russet ring (Pennycook 1989). Red Delicious red ring, apple (Stayman) blotch agent, Stark Delicious ring russeting, Granny Smith leaf pucker bark blister fruit russet and distortion, Granny Smith ringspot, Common Delicious ring russeting, Ballarat leaf pucker agent, McIntosh leaf pucker, Delicious russet ring (NAPPO 2004).	Pennycook 1989, Jones & Aldwinckle 1990, Grove et al. 2003, NAPPO 2004	Yes (Pearson *et al.* 2006; Wood, 1972; Wood, 1979)
Apple McIntosh depression agent			NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple narrow leaf agent			BA 2002, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple necrosis agent		Apple necrosis ilarvirus	BA 2002, WSU 2003, CPC 2007, Brunt *et al.* 1996	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Apple necrotic spot & mottle agent			BA 2002, NAPPO 2004, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple Newton wrinkle agent		apple fruit wrinkle (Newton) (BA 2002, WSU 2003)	NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple painted face agent			BA 2002, NAPPO 2004, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple platycarpa dwarf agent			Wood, 1974	Yes (Pearson *et al.* 2006)
Apple platycarpa scaly bark agent	Apple Platycarpa scaly bark	platycarpa scaly bark agent, apple stem pitting virus? (NAPPO 2004)	Pennycook 1989, NAPPO 2004	Yes (Pearson *et al.* 2006; Wood 1979)
Apple pustule canker agent	apple pustule canker		NAPPO 2004, BA 2002, WSU 2003, Jones & Aldwinckle 1990	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple red ring agent	apple red ring		BA 2002, WSU 2003, NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple ringspot agent	apple chlorotic leaf spot (ACLSV) & severe apple stem pitting virus (ASPV)?; Granny Smith ring spot (CPC 2007)	apple thumb mark, thumb mark, apple Henderson spot agent (NAPPO 2004); apple ringspot disease, apple Henderson spot virus, Apple ringspot virus (CPC 2007)	Pennycook 1989, Dingley 1969, Grove et al. 2003, WSU 2003, NAPPO 2004, CPC 2007	Yes (Pennycook 1989)
Apple rosette agent	apple rosette	apple chlorotic leaf spot trichovirus?	Grove et al. 2003, WSU 2003, BA 2002, NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple rough skin agent	apple rough skin		Jones & Aldwinckle 1990, BA 2002, NAPPO 2004, WSU 2003	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple rubbery wood agent	apple rubbery wood MLO, quince chlorotic blotch, pear rubbery wood disease (CPC 2007)	Apple rubbery wood agent ,Quince bark necrosis virus (NAPPO 2004). Quince yellow blotch agent?. pucker leaf?, rubbery wood?; Pyrusvirus molliens, Quince yellow blotch virus, Apple rubbery wood MLO, apple rubbery wood disease (CPC 2007)	Pennycook 1989, BA 2002, WSU 2003, NAPPO 2004, CPC 2007	Yes (Pearson *et al.* 2006; Wood 1979)
Apple russet ring agent	apple russet ring		Pennycook 1989, WSU 2003, Jones & Aldwinckle 1990, BA 2002, Wood 1979, NAPPO 2004	Yes (Pearson *et al.* 2006; Wood 2001)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Apple russet wart agent	apple russet wart		NAPPO 2004, WSU 2003, Jones & Aldwinckle 1990, BA 2002	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple star crack agent	apple star crack, star crack of apple	Apple horseshoe wound virus (NAPPO 2004); Apple star crack virus, Apple star-cracking virus	Jones & Aldwinckle 1990, WSU 2003, Grove et al. 2003, BA 2002, NAPPO 2004, CPC 2007	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Apple transmissible internal bark necrosis agent		pustule canker ??	NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Quince yellow mosaic agent			NAPPO 2004	No (Pearson *et al.* 2006; Pennycook 1989, PPIN 2009)
Bacteria				
Erwinia amylovora	fire-blight	*Micrococcus amylovorus, Bacillus amylovorus, Bacterium amylovorum, Erwinia amylovora* f.sp. *rubi* (CPC 2007)	blossoms, fruit, stems, leaves, woody parts (Jones & Aldwinckle 1990); stems (CPC 2007)	Yes (Pennycook 1989; NZFungi 2009)
Pseudomonas cichorii	bacterial blight of endive, bacterial rot (CPC 2007)	*Pseudomonas endiviae, Bacterium cichorii, Bacterium endiviae, Bacterium formosanum, Chlorobacter cichorii, Phytomonas cichorii, Phytomonas endiviae, Pseudomonas formosanum, Pseudomonas papaveris, Pseudomonas papaveris* (CPC 2007)	leaves, stems, whole plant (CPC 2007)	Yes (Pennycook 1989; NZFungi 2009)
Pseudomonas syringae pv. *papulans*	blister spot blister spot of apple, blister spot of pome fruit, bark blister, canker (CPC 2007)	*Bacterium papulans, Chlorobacter papulans, Phytomonas papulans, Phytomonas syringae var. papulans, Pseudomonas papulans, Pseudomonas syringae var. papulans* (CPC 2007)	fruit, leaves, buds, leaf scars (Jones & Aldwinckle 1990; BA 2002); leaves, fruit and branches (CPC 2007)	No (Pennycook 1989; NZFungi 2009)

Scientific name	Common name	Synonyms	Commodity association (refs)	Present in NZ (references checked)
Pseudomonas syringae pv. *syringae*	bacterial blossom blast (Jones and Aldwinckle 1990); bacterial canker or blast (stone and pome fruits), bacterial brown spot (beans), bacterial sheath rot, bacterial eye spot, blast of citrus, blister spot of apple, pear blossom blight, bacterial leaf spot, bacterial black spot, apoplexy of apricots, peach-tree short-life (CPC 2007)	*Bacillus cerasi, Bacillus gummis, Bacillus matthiolae, Bacillus spongiosus, Bacterium cerasi, Bacterium cerasi var. prunicola, Bacterium citrarefaciens, Bacterium citriputeale, Bacterium gummis, Bacterium hibisci, Bacterium holci, Bacterium matthiolae, Bacterium nectarophilum, Bacterium prunicola, Bacterium rimaefaciens, Bacterium spongiosum, Bacterium syringae, Bacterium trifoliorum, Bacterium utiformica, Bacterium vignae, Bacterium vignae var. leguminophilum, Bacterium viridifaciens, Chlorobacter syringae, Phytomonas cerasi, Phytomonas cerasi var. prunicola, Phytomonas citrarefaciens, Phytomonas citriputealis, Phytomonas hibisci, Phytomonas holci, Phytomonas matthiolae, Phytomonas nectarophila, Phytomonas prunicola, Phytomonas rimaefaciens, Phytomonas spongiosa, Phytomonas syringae, Phytomonas trifoliorum, Phytomonas utiformica, Phytomonas vignae, Phytomonas vignae var. leguminophila, Phytomonas viridifaciens, Pseudomonas cerasi, Pseudomonas cerasi f.sp. pyri, Pseudomonas cerasi var. prunicola, Pseudomonas cerasi var. pyri, Pseudomonas citrarefaciens*, *Pseudomonas citriputealis*, *Pseudomonas hibisci*, *Pseudomonas matthiolae, Pseudomonas nectarophila, Pseudomonas prunicola, Pseudomonas spongiosa*, *Pseudomonas syringae f.sp. prunicola, Pseudomonas trifoliorum*, *Pseudomonas utiformica*, *Pseudomonas vignae var. leguminophila, Pseudomonas viridifaciens, Pseudomonas vignae, Pseudomonas oryzicola, Pseudomonas holci, Pseudomonas syringae, Pseudomonas syringae pv. japonica* (CPC 2007)	blossoms, fruit, leaves, branches (Jones & Aldwinckle 1990); shoots, twigs, branches, leaves, buds, fruits, stems (CPC 2007)	Yes (Pennycook 1989; NZFungi 2009)
Rhizobium radiobacter	crown gall, bacterial gall, bacterial stem gall, gall, crown knot, root knot, root gall, burr knot, beet crown gall, rosaceae crown gall, crown gall: beet, crown gall: Rosaceae, hairy root: apple (CPC 2007)	*Agrobacterium radiobacter, Agrobacterium radiobacter subsp. tumefaciens, Agrobacterium sp. biovar 1, Agrobacterium tumefaciens, Agrobacterium tumefaciens biotype 1, Agrobacterium tumefaciens biovar 1, Bacillus ampelopsorae, Bacillus radiobacter, Bacillus tumefaciens, Bacterium radiobacter, Bacterium tumefaciens, Phytomonas tumefaciens, Polymonas tumefaciens, Pseudomonas radiobacter, Pseudomonas tumefaciens, Rhizobium radiobacter* (CPC 2007)	stems, trunk (Jones & Aldwinckle 1990); fruits/pods, roots, stems, whole plants (CPC 2007)	Yes (Pennycook 1989; NZFungi 2009)

References for Appendix 1

BA (2002) Biosecurity Australia. Review of Post-Entry Quarantine Protocols for the Importation into Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood. (February 2002). Commonwealth Department of Agriculture, Fisheries and Forestry, Australia; pp 68.

Bradbury, J.F. (1986). Guide to plant pathogenic bacteria. CAB International, Wallingford, Oxon OX10 8DE, UK

Brunt, A.A., Crabtree, K., Dallwitz, M.J., Gibbs, A.J., Watson, L. and Zurcher, E.J. (eds.) (1996). Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996. Available at: http://image.fs.uidaho.edu/vide/

Cadman C H, Lister R M (1961) Some aspects of recent work on soil-borne viruses. *Proceedings of the fourth conference on Potato virus diseases*, Braunschweig, 12-17 September 1960. Wageningen, H. Veenan & Zonen; pp. 17-21

Cropley, R; Posnette, A F (1969) Chat fruit disease of Tydeman's Early Worcester apple. Report of East Malling Research Station for 1968, 137-141.

CPC (2007) Crop Protection Compendium, 2006 Edition. © CAB International, Wallingford, UK, 2006. (http://www.cabicompendium.org/cpc/home.asp)

Dingley, J M (1969) *Records of plant diseases in New Zealand.* DSIR; Wellington.

EPPO (1999) *Data Sheets on Quarantine Pests*: Tobacco ringspot nepovirus. . Available on line at http://www.eppo.org/QUARANTINE/virus/Tobacco_ringspot_virus/TRSV00_ds.pdf

Fauquet, C M; Mayo, M A; Maniloff, J; Desselberger, U; Ball, L A (2005) *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses.* Elsevier Academic Press, London, UK; 1259 pp.

Grove, G G; Eastwell, K C; Jones, A L; Sutton, T B (2003) Diseases of Apple. In Ferree, D C; Warrington, I J (ed) *Apples: Botany, Production and Uses.* CAB International; 459-579.

Hadidi A, Hansen AJ, Parish CL, Yang X, (1991) Scar skin and dapple apple viroids are seed-borne and persistent in infected apple trees. Research in Virology, 142(4):289-296.

ICTVdB - The Universal Virus Database, version 4. Büchen-Osmond, C. (Ed), Columbia University, New York, USA. Available online at http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.056.0.83.011.htm

Jones, A L; Aldwinckle, H S (1990) *Compendium of apple and pear diseases.* American Phytopathological Society Press, St. Paul, Minnesota, USA.

NAPPO (2004) *Guidelines for International Movement of Pome and Stone Fruit Trees into a NAPPO Member Country. Part 1: Viruses and Virus-like Pests, Viroids, Phytoplasmas and* Xylella fastidiosa. North American Plant Protection Organisation, Regional Standards for Phytosanitary Measures No.25.

Németh M (1986) Mycoplasma diseases of fruit trees. In: Virus, Mycoplasma, and Rickettsia Diseases of Fruit Trees. Budapest, Hungary: Akademiai Kaido, 576-578

Paunovic, S; Rankovic, M (1997) Virus diseases of quince in Yugoslavia. 31(3/4): 231-243.

NZFungi (Year of search) New Zealand fungi (and bacteria). Landcare Research New Zealand Limited. Available on line at http://nzfungi.landcareresearch.co.nz/html/mycology.asp

Pennycook, S R (1989) Plant diseases recorded in New Zealand. Vol. 2 & 3. Plant Diseases Division, DSIR, Auckland, New Zealand.

Pearson M N; Clover G R G; Guy P L; Fletcher J D; Beever R E (2006) *A review of the plant virus, viroid and mollicute records for New Zealand.* Australasian Plant Pathology 35 (2): 217-252

PPIN (Year of search): *Plant Pest Information Network*. New Zealand Ministry of Agriculture and Forestry

Thomas H E, Rawlins T E (1950) USDA Agriculture Handbook No. 10.

Wood, G A (1972) Russet ring and some associated virus disorders of Apple (*Malus sylvestris* (L.) Mill.) in New Zealand. Zealand Journal of Agricultural Research, 15: 405-412

Wood, G A (1974) Latent viruses of apple in New Zealand. Zealand Journal of Agricultural Research, 17 (1): 85-91

Wood, G A (1979) Virus and virus-like diseases of pome fruits and stone fruits in New Zealand. Bulletin, Department of Scientific and Industrial Research.

Wood, G A (1996) Past and present status of virus and phytoplasma diseases in apple rootstocks in New Zealand. New Zealand Journal of Crop and Horticultural Science 24 (2): 133-141

Wood, G A (2001) Sensitivity of apple (*Malus domestica*) indicator cultivars to russet resin disease, and the results of graft-transmission trials of other fruit-affecting disorders of apple. New Zealand Journal of Crop and Horticultural Science 29 (4): 255-265

WSU (2003) Washington State University, National Research Support Project 5. *Supporting Research & Development 'Virus Free" Stone & Pome Fruit- Pome Fruit Diseases caused by Viruses (NRSP5) 2001 --Pome Fruit-Virus Detection Procedures (NRSP5), Indexing Procedures*. htttp://nrsp5.prosser.wsu.edu/nrspunkp.html