KPCS target organisms, controls and symptom guide

1. Virus

Virus included:

I. *Cherry leafroll virus* (CLRV)
II. *Actinidia seed-borne latent virus* (ASBLV)
III. Monitor for other unusual symptoms

n 2017, KVH conducted a survey to determine the distribution of two kiwifruit viruses known to exist in NZ *Actinidia seed-borne latent virus* (ASBLV) – formerly known as Betaflexiviridae, and *Cherry leafroll virus* (CLRV).

Distribution of these viruses is limited with no positive results from this survey. This is good news for the industry and indicates there is value in including these organisms in the KPCS to ensure they remain in limited distribution.

Only plants propagated from seed or cuttings sourced from certified virus free mother plants will be allowed to be moved under the KPCS. Testing will be completed annually at nursery cost with testing reduced to five yearly after two consecutive virus free results. The nearest male pollinator will also be required to be tested.

Summary
Control of known kiwifruit viruses is best achieved by sourcing clean starting material. Therefore, the focus of KPCS measures is testing of mother plants and monitoring for virus-like symptoms.

Rationale for viruses selected:

- Of the 16+ viruses known to infect kiwifruit, only CLRV and Pelargonium Zonate Spot Virus (PZSV) are known to induce disease.
- CLRV is present in New Zealand with a limited distribution and has been included to prevent further spread. Mode of transmission of CLRV is not yet known, likely pollen, seed and tools.
- PZSV has not been reported in New Zealand, but would be included as a target organism if found to be present here
- ASBLV has only recently been discovered and while evidence to date suggests that it is not associated with disease symptoms there is little is known about this virus and there may be potential impacts that are not yet apparent.

Controls

- No new control measures added to the KPCS Standard for virus control.
- These viruses are primarily transmitted vertically, i.e. through infected plant material used in propagation and horizontally through infected tools.
- Therefore, focus is on ensuring incoming material is clean (seeds, seedlings and budwood) with diagnostic testing, tool hygiene using existing controls and monitoring for symptoms to provide early detection of infection.

Monitoring

- Monitoring of mother-plants and source material will provide additional confidence to support diagnostic testing.
- Nurseries are to be familiar with general symptoms typical of viral infection such as leaf chlorosis, leaf cupping, leaf or vein chlorosis and chlorotic mottle.
- The presence of symptoms must be reported to KVH and diagnostic testing may be required.

Testing

- All mother-plants tested for target viruses (CLRV and ASBLV). For seedling production, the nearest pollinator will also require testing.

- Due to the nature of virus transmission, plants that return not-detected results do not need to be tested every year repeatedly. For plants that return two consecutive non-detected results, testing can be reduced to once every 5 years.
- Testing will be done in March, when CLRV is the highest and most likely to be detected.

Virus Symptom Guide

Nurseries must be aware of symptoms typical of viral infection and monitor their plants for these, especially during spring and late summer when symptoms are most likely to be expressed.

Generic symptoms of viral infection:

Symptoms typical of viral infection may look like herbicide damage or a nutritional deficiency.

- Mosaic leaf pattern
- Crinkled leaves
- Yellowed leaves
- Stunted growth

Figure 1. Kiwifruit leaves from China displaying symptoms typical of viral infection (however the cause of the symptoms above is unknown).

Cherry leaf roll virus

Symptoms:

- leaf mottle (blotchy spots)
- vein yellowing
- pale spots that turn necrotic (dead tissue)
- cane dieback and cracking
- altered fruit shape and structure

Figure 2. Cherry leaf roll virus-infected Gold3 plants exhibit vein chlorosis (left) and leaf curl (right). Images from Samantha Edwards, PFR

Pelargonium zonate spot virus

In Italy, symptoms appear on kiwifruit vines in early spring and remained evident until the end of the season in plants with severe infection. However, plants with mild or sectorial symptomatic infection symptoms disappear in summer. Therefore, visual monitoring for disease symptoms should concentrate on the spring period when symptom expression is greatest.

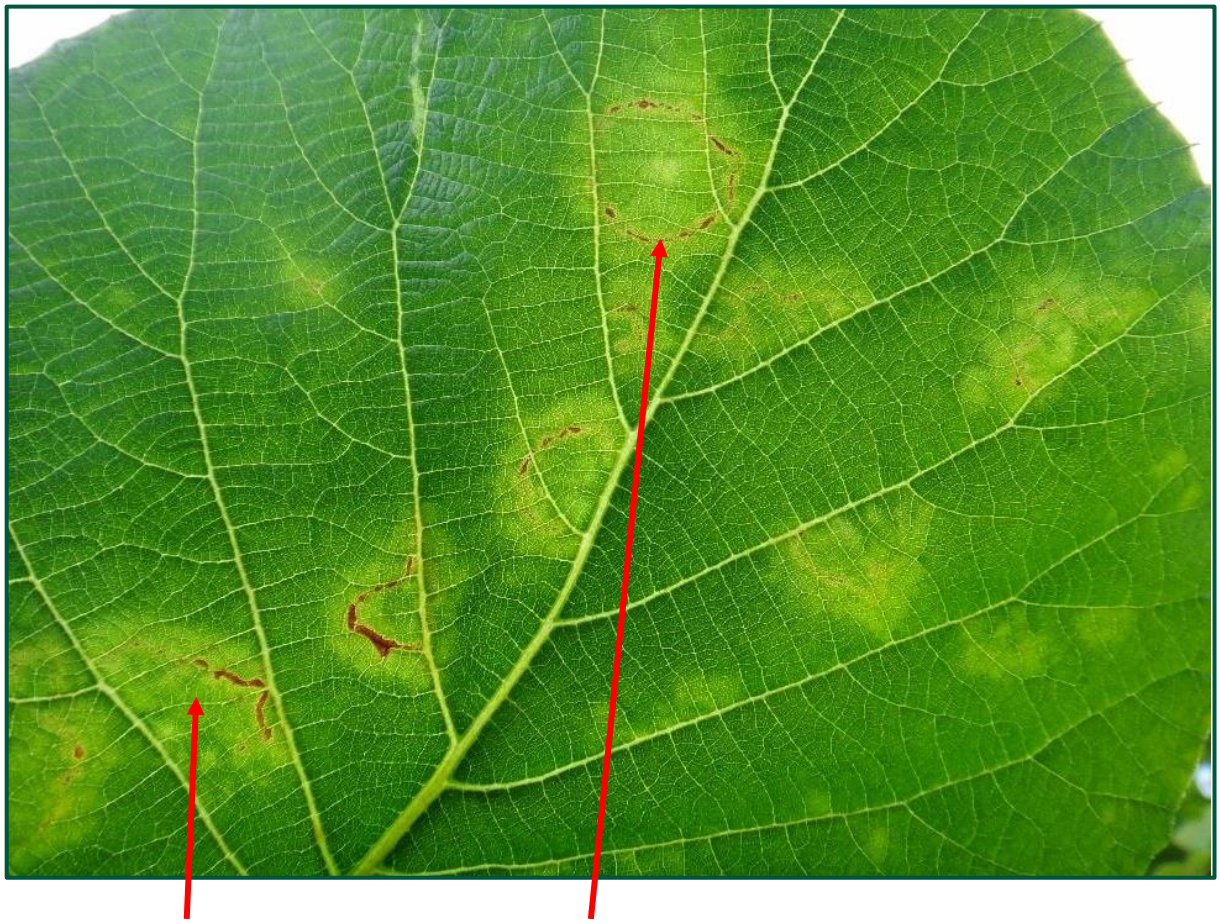

Figure 3. Chlorotic halo (pale spot) and necrotic ringspots (ring of dead tissue) on *Actinidia chinensis* 'Hort16A' leaves caused by *Pelargonium zonate spot virus.* Image from Arnaud Blouin, Plant & Food Research.

2. Soil invertebrates

I. Root knot nematode (RKN)

Summary
Control of RKN can be best achieved by following best practice advice and monitoring plants for typical symptoms. The roots of any symptomatic plants must be checked for the presence of galls and if present treatment is required prior to dispatch.

Rationale

- Root knot nematodes feed on kiwifruit roots, damaging the root system and decreasing the vine's nutrient and water use efficiency. Host plants will be affected by loss of turgidity, retarded growth and reduced fruit size.
- Root knot nematodes have also been reported to reduce a plant's disease resistance and increasing the likelihood of disease
- Worldwide there are around 100 species of root knot nematodes, infecting a range of plant species. *Meloidogyne hapla* and *M. fallax* are the main species infecting kiwifruit in New Zealand.

Controls

- Nurseries must exhibit control over plan weed species (added as a requirement under "PF.1; Pest Free Place of Production"): RKN have a wide host range and can multiply on weed hosts, especially solanum weeds (such as black and wooly nightshade).
- Existing measures such as hygiene and best practice advice should be followed to reduce risk of nematode infection.

Best practice advice

1. <u>For containerized plant production:</u>
    - Only clean containers to be used.
        - New containers do not require disinfection but must be stored above floor level (i.e. on pallets at a minimum) and free of soil, plant material and water contamination.
        - Used containers should be cleaned of waste material and treated with an approved sanitizer (such as soaked in 0.4% hypochlorite for 20 min).
    - Growing media; There is no need for further disinfestation if potting mix is sourced from material considered to be pathogen free (such as perlite, vermiculite and peat moss) or is sourced from a supplier with a pathogen control program in place.
    - Growing media that doesn't meet the above requirements may contain pathogens and therefore should be treated using heat (>60 ^{o}C for 30 min) or a fumigant.
2. <u>For field grown plants:</u>
    - Nematode free production sites should be used
    - When selecting a new nursery any weeds in the field should be tested for RKN infection along with soil DNA test.
    - Select a non-coarse site if possible as nematode damage is more severe in sandy soil.
    - Organic amendments: There are a range of organic products that have biocide properties and used in controlling disease and the presence of nematodes that may be used at nursery discretion

Monitoring

- Nurseries are to monitor for symptoms of root knot nematode (RKN) which include stunted growth, appearance of water stress and loss of turgidity (wilting).
- Where symptoms are present, roots should be examined for root galls

Testing

- Testing not required as routine practice, but may be required for diagnosis of symptomatic plants.

Treatments

- Symptomatic plants with galls present must be treated with a bare root dip in a non-phytotoxic chemical prior to dispatch.

RKN Symptom Guide

If plants display any of the following symptoms, their roots should be inspected for the presence of nematodes;

- Stunted growth
- Loss of turgidity (wilting)
- Appearance of water stress

Root knot nematode symptoms

The first sign of infection is galling on the roots (indicated with red arrows below). Root galls are large knots or the appearance of swelling.

Figure 4. Early infection of kiwifruit seedlings by root knot nematodes.

3. Soil borne fungi and Phytophthora

I. *Verticillium albo-atrum* (Verticillium wilt)
II. *Ceratocystis fimbriata (*Ceratocystis wilt)
III. *Phytophthora* species
IV. Monitor for other unusual symptoms

Summary
Control of soil borne fungi and *Phytophthora* is best achieved by following best practice advice and existing controls within the KPCS. Nurseries are not required to implement any additional controls however they must monitor for symptoms.

Rationale
A number of soil borne pathogens have been associated with kiwifruit. The pathogens whose spread could result in the most significant impact to the industry are *Verticillium albo-atrum* (Verticillium wilt) and *Ceratocystis fimbriata*, neither of which are known to exist in New Zealand (in a form pathogenic to kiwifruit).

Phytophthora (not true fungi but "fungi like") are a well-known group of pathogens responsible for significant impacts to many plant industries around the world. Nursery plant movements have often been associated with the spread of invasive *Phytophthora* species and therefore a primary focus of many nursery biosecurity schemes internationally. Worldwide there are more than 100 species of *Phytophthora.* We don't fully understand the threat *Phytophthora* present to kiwifruit but do know that there are several pathogenic species in New Zealand; and several other species pathogenic to kiwifruit offshore.

The risk of spreading fungal pathogens will be reduced with through existing controls in the KPCS Standard and monitoring for symptoms. As the most significant threats are not present in New Zealand, diagnostic testing will not be required as routine practice, however plants showing symptoms typical of fungal pathogens may be referred to a laboratory for diagnostic testing.

Controls
- The risk of these soil borne pathogens is mitigated through high health practices already included in the KPCS Standard such as tool and visitor hygiene.
- Best practice recommendations include
    - Growing media sterilized and / or sourced from a supplier with a comprehensive disease prevention program to prevent introducing pests or pathogens.
    - Potted plants should be grown on a soil free surface, such as a concrete platform or gravel. Ideally plants would be grown on raised benches on a clean concrete platform (70cm to top of pot) to avoid contamination from soil splash.
    - Field grown plants should be grown in areas with good drainage. Most soil borne pathogens thrive in poorly drained environments.

Monitoring
Nurseries will be provided with symptom guides and as part of monitoring rounds will look for symptoms of the most significant fungal threats *Verticillium albo-atrum* (Verticillium wilt), *Ceratocystis fimbriata* and *Phytophthora* species. Staff undertaking monitoring will require training to ensure they are familiar with the symptoms.

Testing
Diagnostic testing for fungal pathogens will not be required as routine practice but may be required to identify the cause of symptoms if fungal pathogens are suspected.

Soil borne fungi and Phytophthora Symptom Guide

Verticillium wilt

Leaves often show wilting and marginal and interveinal necrosis. Shoots in early stage of elongation wilt and die back from tip.

Symptoms:

- Stunting
- Wilting
- Dieback
- Discolouration of new growth

An infected plant (on the right) is compared to a healthy plant (left) to illustrate the stunting of growth, dieback and discoloration on the leaves.

A new shoot that is showing discoloration, wilt and dieback

Discoloration and wilting of leaves

Comparison of infected plant (left) to a health plant on the right, showing the loss of vigour and stunted growth

Ceratocystis fimbriata

Symptoms:

- leaf curl and wilt
- shrivelled canes
- darkened xylem tissues that are evident when the bark and inner wood is cut down the side of the trunk

Affected vines have reddish-brown staining in a radial pattern in the xylem and that the disease reduces the number of harvestable fruit. Most affected plants die.

3. Bacteria:

I. Psa (all forms)
II. Monitor for other unusual symptoms

Summary

There are multiple forms of Psa, in New Zealand and offshore. All forms are included as target organisms within the KPCS, although "*Restricted Certification*" plants are permitted to have the "common" form of Psa-V.

KPCS controls will reduce the likelihood of infection by other bacterial threats, although nurseries should be vigilant in their monitoring rounds and report any unusual symptoms.

Rationale

KPCS 'full certification" plants must be free of all forms of Psa (NZ and non-NZ biovars and forms resistant to crop protection products). Plants with the "common" NZ form of Psa (that are free of non NZ and resistant / tolerant forms of Psa) may be certified for movement within their growing region under the KPCS "Restricted Certification" label.

There are other bacteria pathogenic to kiwifruit other than Psa such *Pectobacterium carotovorum* subsp. *actinidae* which has caused significant impacts in Korea but is not present in New Zealand. However, no further controls are recommended as existing controls to mitigate the risk of Psa are also likely to mitigate the risk of other bacterial pathogens, provided that nurseries monitor for and report unusual symptoms.

Controls

The KPCS Standard has been written with bacterial threats such as Psa in mind. Therefore, a number of controls exist to mitigate the risk of bacterial threats.

Monitoring

Nurseries must be very familiar with symptoms associated with Psa, and monitor for these but report any unusual plant symptoms.

Testing

Comprehensive end of process testing for Psa. KPCS "*Full Certification*" plants must return a non-detected result. KPCS "*Restricted Certification*" plants may have the common form of Psa-V, but return a non-detected result for non-New Zealand and resistant forms of Psa.

Symptom guide

A specific and detailed Psa-V symptom guide is available on the KVH website (www.kvh.org.nz/vdb/document/870)

Symptoms of Psa strains resistant to Streptomycin or Copper will look the same as non- resistant strains, and therefore can't be distinguished visually.

This may also be true for non-New Zealand strains although in some cases offshore strains of Psa have induced different symptoms in kiwifruit, such as the pale halos in the image opposite..

Therefore, nurseries should be very familiar with Psa symptoms and report plant symptoms resembling these, or any plant symptoms where the cause is unknown.

Symptoms of Psa Biovar1 on Hayward in Japan