Pseudomonas syringae pv. *actinidiae*-Virulent Impacts on the New Zealand Kiwifruit Industry©

Linda Peacock
Kiwifruit Vine Health, PO Box 4246, Mount Maunganui 3116, New Zealand
Email: linda.peacock@kvh.org.nz

Pseudomonas syringae pv. *actinidiae*-Virulent (Psa-V) was first detected in Te Puke in the Bay of Plenty in November 2010. Since then, the disease has spread to most New Zealand kiwifruit-growing regions, affecting 2,256 orchards [Kiwifruit Vine Health (KVH) statistics as of Sept. 2013]. This equates to around 75% of kiwifruit-growing hectares.

Pseudomonas syringae pv. *actinidiae*-Virulent is a gram negative flagellated bacterium (Fig. 1) that can spread through weather, namely wind and rain, and through the movement of infected plants, rootstocks, plant material, contaminated orchard machinery, tools, equipment, and people. It causes disease to kiwifruit vines only, and poses no risk to human or animal health. Some kiwifruit cultivars, such as Hort16A, are more vulnerable to Psa-V than others. However all cultivars are susceptible to the disease. Therefore, best-practice management must be applied to all cultivars, in all regions, to help achieve successful growth in a Psa-V environment.

The Psa-V infection pathway is via natural plant openings such as stomata, lenticels (Fig. 2), broken trichomes, and petiole scars. It can also infect plants through man-made wounds such as pruning, grafting and girdling; and natural plant damage such as wind, frost, and insect damage. Once the disease progresses into the plant vascular system (xylem and phloem) and becomes systemic, there is no cure for Psa-V.

Fig. 1. Magnified *Pseudomonas syringae* pv. *actinidiae*-Virulent.

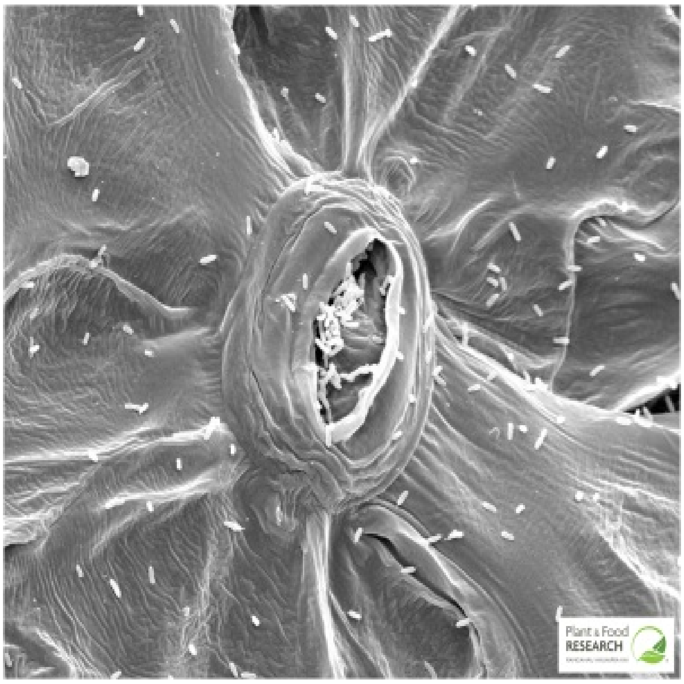

Fig. 2. Magnified stoma and bacteria.

Primary Psa-V symptoms include angular-shaped leaf spots that are often, but not always, surrounded by a halo (Fig. 3). Brown discoloration of flower buds and cane die-back indicate secondary disease symptoms and the advanced stages of infection, produce red and white exudates (Fig. 4) associated with cankers.

Fig. 3. *Pseudomonas syringae* pv. *actinidiae*-Virulent leaf spotting on *Actinidia deliciosa*.

Fig. 4. White exudate is essentially pure *Pseudomonas syringae* pv. *actinidiae*-Virulent inoculum.

GLOBAL EXPERIENCE

Pseudomonas syringae pv. *actinidiae*-Virulent was first identified in Italy in 1992. It is now widespread in the main growing regions of Piedmonte, Veneto, Emilia Romagna, and Lazio. Frost-prone areas have been impacted more severely.

In France, Psa-V was first reported in 2010. Within 2 years around 18% of industry was affected across most regions and multiple cultivars. A different, less-virulent strain of Psa has been recorded since 1989 in Japan. In South Korea, Psa was first confirmed in 1992 where it went on to severely damage the industry. Eight orchards in the Maule region in the South of Chile tested positive to Psa-V. This includes an area of 159 ha of multiple cultivars. Spain, Portugal, and Greece have also reported cases.

Anecdotal evidence is that Psa-V has been present in China for some time.

NEW ZEALAND EXPERIENCE

When Psa-V arrived in New Zealand, it hit rapidly and severely (Figs. 5). It particularly devastated the original Zespri®Gold kiwifruit cultivar, 'Hort16A'. Shortly after the first reported case in Te Puke, KVH was established to lead the industry response to Psa-V on behalf of the New Zealand kiwifruit industry. The industry needed to understand the disease and its impacts on various commercial cultivars, and how to successfully grow kiwifruit in a Psa-V environment.

Fig. 5. Orchards cut out due to Psa-V infection.

A case study carried out by KVH on Te Puke ‘Hort16A’ orchards (Hardy, 2012) illustrated the impact on orchard productivity for this most vulnerable cultivar. The study followed 57 orchards identified with Psa-V by 2011 harvest (May/June). Only 6 of the 57 orchards made it to the following harvest. Of the 147 ha represented in the case study, almost 127 ha were cut out (Fig. 6). Of the 20.2 ha that were not cut out, the average production was reduced to 31%. Trays harvested from the 57 orchards fell from approximately two million (2010) to 1,600,000 (2011) to 127,000 trays in harvest 2012 (Fig. 7).

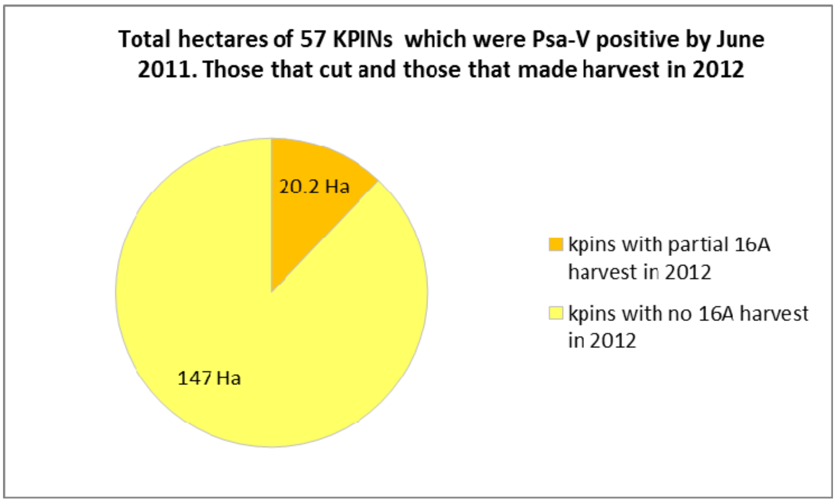

Fig. 6. The impact of Psa-V on the 2012 harvest for the 57 KPINs (Kiwifruit Property Identification Numbers) followed in KVH’s 2012 case study.

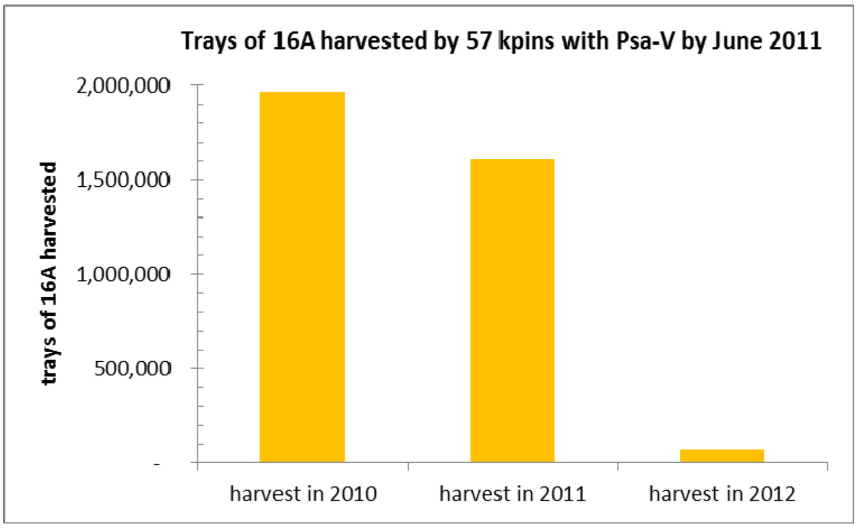

Fig. 7. Orchard productivity fell in 2 years from about two million trays to 127,000 trays for the 57 properties in KVH's case study. Note the numbers shown represent these properties only, not national harvest figures.

The economic impact of Psa-V is huge. Lincoln University Agribusiness and Economics Research unit released an impact report in May 2012, conservatively estimating an industry cost of $310 million through immediate disease impact and $410 million due to response costs. The disease cost in terms of lost development was estimated between $740 and $885 million. Job loss represented a further tier of economic concern.

Eighteen months after Psa-V was first found in New Zealand, the widespread release of 'Gold3', Zespri®SunGold occurred. 'Gold3', a kiwifruit cultivar commercialised in 2010 by ZESPRI, was found to be less susceptible to Psa-V and was identified as the "recovery pathway" for the industry.

At this time, 40% of the country's kiwifruit orchards were recorded as Psa-V positive. Infection levels ranged from low levels of leaf-spot to entire orchards removed due to the disease.

INDUSTRY STEPS TOWARDS RECOVERY

A significant step in the recovery pathway process was taken in 2011/2012 when 1,860 ha of 'Hort16A' were grafted across to 'Gold3'. This represented almost 15% of New Zealand's kiwifruit growing area converting to this new cultivar.

Infected orchards that were originally cut out due to Psa-V, and re-grafted in July/August 2011, had shown an average grafting success of 85% across the group. Individual orchard success rates ranged from 65 to 100%. High levels of site infection, stump dieback, and poor grafting were thought to have reduced success from historical 90-95% graft success rates.

The Zespri Smartkiwi trial set up in summer of 2011 to provide more information about the ability to complete summer grafts on a site exposed to Psa-V inoculum averaged a 96% graft success rate. Some Psa-V symptoms were observed on the new grafts.

In 2012, Zespri Orchard Productivity Centre (OPC) undertook a number of grafting trials and a winter graft-take monitoring survey in Te Puke to establish the success of this industry grafting operation. The monitoring survey showed graft-take tended to be higher (on average 10% higher) on stumps with no obvious Psa-V symptoms.

Lower graft-take was observed on orchards that were cut the season prior to grafting. This suggested stump health may become compromised when left for long periods between cut-out and grafting.

Traditional cleft and kerf grafts outperformed a different “staghorn” graft technique (Figs. 8 and 9). The staghorn technique had been adopted in a bid to reduce cost and time. This method proposed a single junction between scion and rootstock cambium would be sufficient to provide graft takes. However, in practice, blocks using this method required re-graft. This re-emphasised the importance of correct scion placement with alignment of cambium. Scion cambium placed inside the stump cambium lead to graft failure.

Fig. 8. Unsuccessful staghorn graft method.

Fig. 9. Successful kerf graft.

A trial was also carried out to see if Psa-V could spread between kiwifruit vines through the contamination of products used for protecting wounds post-grafting. Transfer was observed, therefore the recommendation was to use a protectant containing a bactericide.

Graft success was also affected by Spring 2012 frosts. Sites where stumps were cut 0.5 m from the ground, to ensure removal of susceptible ‘Hort16A’ interstock, were most affected.

No significant differences in the rate of graft establishment were observed when different levels of nitrogen were applied on sites with mature stumps.

Young ‘Bruno’ rootstock expressing white Psa-V exudate was grafted following the removal of infected Hort16A plants was completed. Graft-take was significantly lower than the industry average, with a 55% success rate. However, suckers grew from a number of these rootstocks and provided a second summer grafting opportunity.

GOING FORWARD

Zespri's breeding programme, through Plant and Food Research, has the challenge of developing a long-term solution for the New Zealand kiwifruit industry. Commercially viable cultivars, with a marked improvement in Psa-V tolerance, are unlikely to be available until 2018. However, cultivars with some improvement may be available by 2016.

To manage Psa-V effectively, the industry must work collectively at an orchard, regional, and national level. To achieve this, KVH developed the National Psa-V Pest Management Plan (NPMP). The NPMP was approved by the Ministry for Primary Industries, and came into effect in May 2013.

Key objectives of the NPMP are to keep Psa-V out of regions where it has not yet been detected, and help lower inoculum levels in Psa-V infected areas (Fig. 10). Under the NPMP, protocols have been formally established to restrict the movement of all high-risk items and help reduce the spread of Psa-V. High-risk items include budwood, nursery stock, plant material, and orchard machinery and equipment. Growers, postharvest, and all those industries associated with the kiwifruit industry will continue to work together to provide the best chance of industry success going forward. Information about best-practice orchard management is available in the KVH Seasonal Management Guide on the KVH website <www.kvh.org.nz/seasonal advice>.

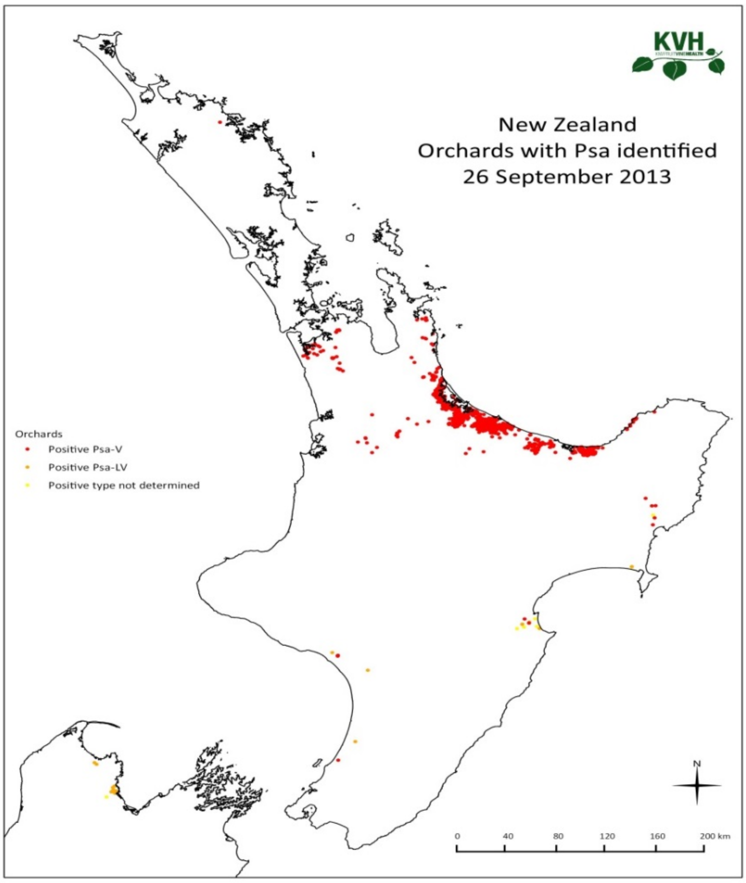

Fig. 10. Current New Zealand Psa-V status.

ACKNOWLEDGEMENTS.
Photo acknowledgement: Figures 1 and 2 supplied by Plant & Food Research, New Zealand. Further information: Kiwifruit Vine Health website <www.kvh. org.nz>.

Literature Cited

Chamberlain, J. and Max, W. 2013. What did we learn from the 2012 winter grafting season? Zespri, NZ Kiwifruit J. May/June.

Hardy, C. 2012. Case study: Psa-V positive Hort16A orchards in Te Puke — key factors in reaching 2012 harvest. Kiwifruit Vine Health.

KVH Seasonal Management Guide. 2013. <www.kvh.org.nz/seasonal advice>

Oats, L., Peacock, L. and Jones, V. 2012. Summer grafting success on a high inoculum trial site — preliminary Zespri Smartkiwi project results. Kiwifruit Vine Health, NZ Kiwifruit J. May/June.