Management of *Pseudomonas syringae*

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The outbreak of *Pseudomonas syringae actinidiae* (PSA) in kiwifruit orchards in the Bay of Plenty is unfortunate for an industry which prides itself as almost spray free. Depending upon the pathogenicity of the PSA pathovar, a regime of regular sprays will be required if this pathogen is to be controlled.

The first signs of infection are often chlorotic spotting, which is caused by a toxin (syringomycin from *Pseudomonas syringae*) entering leaf tissues where it disrupts cell/organelle membranes. The angular, necrotic spots result from a hypersensitive response by the host in which tissues die suddenly to deny the bacterium access to cellular contents (Spiers et al 1989).

P. syringae can cause extensive stem and branch dieback during spring following a cold night when adequate moisture is present. Many plants, including kiwifruit, exhibit extensive chlorosis, which may surround a pin-point necrotic spot. Other symptoms include angular to irregularly shaped necrotic spots which under favourable conditions may become confluent and involve the whole leaf or whole shoots which collapse and turn necrotic.

All bacterial diseases are assisted by rainfall and frost and accordingly symptoms will become more prevalent after a wet late winter and spring.

P. syringae occurs over a wide host range and no single isolate will infect all recorded hosts. Many are host specific and accordingly are listed as pathovars (Young et al, 1978; Dye et al 1980). Much of my experience regarding the outbreak of bacterial infections is confined to poplar and willow stool beds where ideal conditions for disease expression exist in early spring when there is a massive expansion of soft growth (Haworth &Spiers, 1988). This is no different to the rapid shoot growth observed in kiwifruit. The behaviour of *P. syringae* on poplars in Palmerston North during the 1985-1986 growing season is relevant to the occurrence of PSA in kiwifruit and is worth reviewing as it will give an insight as to how PSA will perform in NZ.

The severity and frequency of *P. syringae* infection on one and two year old poplars during the 1985-86 seasons was atypical. Leaf spotting (pale yellow areas, discrete angular spots and extensive necrosis) was extensive, leaves and side shoots were shrivelled, necrotic and desiccated. Stems were cankered and fissured, buds were necrotic and bacterial slime oozed from infected areas. In previous years the incidence of leaf spotting was light and infection was sporadic and limited to terminal and lateral shoot dieback. Examination of climate records during the period when severe attacks of *P. syringae* were experienced (November-February), rainfall was 64% more (194 mm more than average) and rain fell on 52 out of the 120 days during the period. Numerous studies have underlined the key role of rain in determining the magnitude of epiphytic and stem populations. Latorre et al (1985) reported populations of *P. syringae* greater than 10,000-100,000 cfu/g of bud tissue only during wet periods then declined to low or undetectable levels during dry periods.

Severe attacks of *P*. syringae are commonly associated with frost. Tissue dieback is extensive and it is impossible to distinguish between frost and *Pseudomonas* damage. The association between frost damage and *P. syringae* has been reported many times and the rationale was explained by Arny et al (1976) who showed that cells of *P. syringae* initiated ice-nucleation, which in turn caused tissue damage. Fifty percent of the *P. syringae* isolates from poplars tested positive for ice-nucleation. Isolates from kiwifruit should be tested to see if they can initiate ice-nucleation and hence exacerbate the threat from frost. Attacks of *Pseudomonas syringae* on different host species are often confined to one-two year old wood and spring regrowth often in association with frost. The incidence and severity of bacterial diseases appear to be strongly determined by high rainfall, cold spring weather and the occurrence of frost. If such conditions are present a strong control strategy should be implemented. The control strategy will require sequential sprays as very few treatments last for more then two weeks.

Elicitor based products are ideal in dealing with these outbreaks as they stimulate the plants defence system as well as dealing with the bacteria directly. These products are applied at 10- 14 day intervals even when it rains most days in early spring.

Products used to control Bacteria.

Controls have focused on Copper based products, that have proved their efficacy over the year, but should not be seen in isolation. There are other products that can be used alongside a Copper programme to both enhance the defence systems in the plant and also assist in controlling the bacteria.

Copper based products.

Numerous formulations of copper have been used to control bacteria for years. These include copper hydroxide (Blue Shield/Champ/Headland Choice/Kocide) copper oxychloride (Agpro Copper/Oxychloride 800WP/Fruitfed Copper Oxychloride), Cuprous oxide (Nordex) and copper sulphate). There are environmental concerns re the accumulation of copper residues in the soil which is currently a problem facing the Avocado industry. Young leaf tissues and flowers may be damaged by copper.

Streptomycin.

This is applied at 100ppm (60g/100L of 170g/Kg). Streptomycin has strong activity against bacteria however it may not be acceptable to spray kiwifruit because of the public's aversion to spraying food crops with an antibiotic. This concern arises from use of Streptomycin in human and animal medicine and the spectre of resistance. Notwithstanding, the committee on antibiotic resistance has not detected a major shift in Streptomycin resistance possibly because of the limited use of the product.

Phosphorous acid.

This product, gives inconsistent control of bacteria however because of persistent phosphite residues in the fruit, phosphorous acid should not be applied to kiwifruit. ManKocide has given inconsistent results and is probably less effective than cupric hydroxide applied alone.

Elicitor-based sprays

An elicitor is a substance that triggers induced resistance /hypersensitive response in a plant. The elicitors interact with the plasma membrane of undamaged cells and trigger activation of genes involved in the defence response. The precise nature of this signal transduction mechanism is still unknown but is very powerful and can last for up to 20 days. Omnia have been using elicitors to enhance the response of plants to pathogens (Bacteria, Black Spot, Powdery Mildew, and Rust) and also to increase firmness of leaves and fruit. Elicitors can enhance the activity of co applied fungicides and delay the development of host resistance. Helping the plant help itself is the key to elicitor technology. As this concept is developed the distinction between elicitors, nutrients, bactericides and fungicides will become obscured.

Spotless

This is a multifunctional elicitor product developed by Omnia. The product has three key modes of action, being bacterial, fungicidal, and elicitor. These modes both deal with the infections and empower the plant's defence system.

Proof of Elicitor Effectiveness

During spring 2009 and 2010 Walnut and weeping crab apple trees and Hawthorn were sprayed at 14 day intervals with elicitors from bud burst until 31st December. In both years sprayed leaves remained free of bacterial lesions (Figures 2 & 3). Spring 2009 was particularly wet and for the period from September until the end of December it rained on 60 out of 121 days with 466mm of rain.

Weeping Crab Apple - Sprayed Leaves

Unsprayed foliage infected with *Xanthomonas arboricola pv juglandis* and *Pseudomonas syringae pv syringae.*


Walnut - Sprayed Leaves


Unsprayed foliage infected with *Xanthomonas arboricola pv juglandis* and *Pseudomonas syringae pv syringae.*

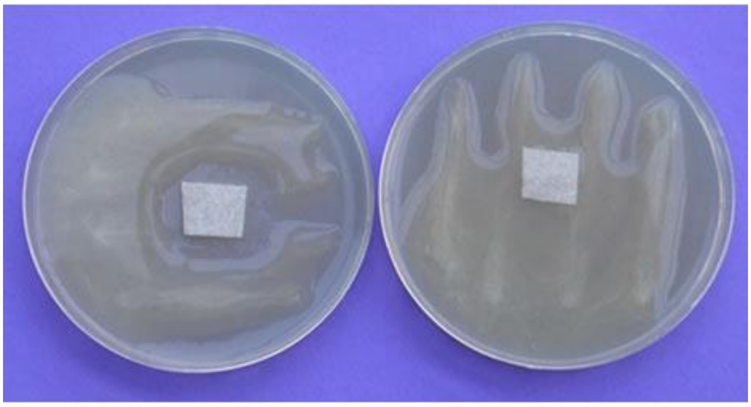
The last image shows induction of resistance in Lombardy poplar following elicitor applications. The spray has “switched on” resistance genes which were not know to exist in this cultivar. The resistance genes have invoked a hypersensitive reaction in rust colonised tissues which have killed the rust infection.

The power of the elicitors is demonstrated by the first two sets of images and the ability to control leaf spotting and necrosis on Hawthorn. Although the bacteria on these hosts were not identified, *Erwinia, Pseudomonas* and *Xanthomonas* would have been present.

In Vitro Testing

A simple screening system was developed whereby four lines of bacteria were streaked equidistant on the surface of 1.5% Malt agar. The bacterium used was a highly motile strain of *Enterobacter* isolated from stained wood from kiwifruit. Following streaking, a filter paper square soaked in a 1% solution of the product under test was dried briefly on tissue paper then placed in the centre of the plate. The inoculated plates were dark incubated at 22ºC for 20 days. Inhibition of growth was monitored every 5 days.

This test gives an indication of activity and does not account for induction of host resistance. Figure 5 shows inhibition of *Enterobacter sp* after 20 days by Elicit (Left) (1.5ml/L) and Streptomycin (Right) (0.8g/L).



Inhibition of *Enterobacter* after 20days by Elicitors (Left) and Streptomycin (Right).

Spray Regime for PSA

An effective spray regime to manage PSA on kiwifruit should aim to keep the population of bacteria to low levels. This would require a spray regime which was highly attuned to rainfall during early spring and summer. It is proposed that elicitor based products should be sprayed at 10 - 14 day intervals during wet periods. Omnia has developed Spotless and Omiwett which are ideal for use in this period.

The currently registered spray of Spotless over the flowering period for control of *Sclerotinia* would further assist the management of bacteria.

Summary

Effective management of PSA disease of kiwifruit should be possible if a tight weather based spray programme is instituted. This programme should embrace plant elicitor technology, in addition to the Copper based programmes.

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