Autumn Spraying for Protection from Psa
PROJECT CODE Zespri 24
VI1512

Report Prepared For Zespri International Limited

Prepared By: **Lynda Hawes** B.Hort.Sci.
Horticultural Consultant
HortEvaluation Ltd

January 2015

1.0 Executive Summary

Zespri engaged HortEvaluation Ltd and Lewis Wright Valuation & Consultancy Ltd to undertake a trial to verify the importance of post-harvest spray protection, explore options for Psa protection post-harvest and further explore the effect of forced leaf drop on the expression of Psa symptoms in the following spring.

The trial was carried out at two sites, site one near Te Puke on a commercial producing Gold 3 orchard which had Psa present and site two, in Nuhaka, Northern Hawkes Bay on a Hort16A block which was due for cut out in winter 2014. At Nuhaka, the owner retained a portion of the block through to spring 2014, to allow the trial to be undertaken, while the balance of the Hort16A area was cut out.

At site one, the pre-harvest interval for soil applied Actigard could not be met, to enable the grower to harvest at the time intended, so this application for treatment three was not made. Frost on 27-29 May rapidly hastened leaf fall and voided the opportunity for application of copper sulphate intended as part of treatment six, to hasten leaf fall. Leaves fell very quickly after these frost events. Pruning was undertaken as soon as a break in the wet weather around 17-20 June occurred, before the pre–prune treatments were applied. These treatments were therefore applied immediately post-prune on 21 or 22 June 2014.

At site two, applications were made as intended. However, no pruning as such was undertaken on site, because the grower planned to remove all canopy at the completion of the trial. Therefore, no winter pruning was necessary.

Applications were otherwise as intended.

Treatments were replicated eighteen times. Plots were grouped big plots of six per treatment at site one and fully randomised at site two. Each plot was a vine.

Treatment one was established as the standard programme, using a copper protectant plus an elicitor immediately post harvest, followed by a copper protectant and elicitor three weeks later, followed by a copper protectant at late leaf fall, again at pre prune and again immediately after pruning.

Treatment two was as for treatment one, plus Key Strepto and Engulf at late leaf fall timing, to explore any differences in leaf scar protection.

Treatment three was as for treatment one, plus soil applied Actigard before harvest and three weeks post harvest at site two; and three weeks post harvest at site one.

Treatment four was as for treatment one, but substituted Ambitious for Actigard in the immediate post harvest and three weeks later spray applications.

Treatment five was a copper programme only, for all post-harvest applications.

Treatment six omitted the two immediate post-harvest applications, added copper sulphate during leaf fall (for site two only), then as for treatment one.

Treatment seven was as for treatment one, plus Key Strepto and Engulf at late leaf fall and again before winter pruning (after winter pruning at site one). This treatment showed some potential for reduced Psa symptoms in a previous trial.

Treatment eight was the minimal copper programme, involving no post harvest applications, one application at late leaf fall, one application before and a further application after winter pruning.

At site one male vines received treatments one, six and eight, as for the Gold 3 vines.

ACVM permission was obtained to apply Key Strepto with Engulf and fruit was subsequently collected for residue testing in 2014.

Leaf samples were collected from the Gold 3 site, for Actigard (treatment one), Ambitious (treatment four), versus the copper-only programme (treatment five) versus no application (treatment eight), to enable analysis of vine metabolite profiles. Samples were stored in a -80°C freezer for later metabolite analysis, if warranted as a result of treatment effects.

Vines were assessed for Psa symptoms in twice in spring 2014. At site one, vines were assessed for secondary symptoms such as cane dieback, cane and leader cankers prior to the orchard manager removing Psa symptoms evident at each time. At site two, due to the very rapid development of Psa symptoms, number of leader cankers, percentage live canopy per plot and a cane dieback score were recorded.

Return bloom was monitored at site one by AgFirst undertaking components of yield bud, shoot and flower counts for five canes on each vine.

Data were analysed by analysis of variance, with raw data typically square root transformed to normalise the variability. At site one, many variables had too many zeroes to be analysed separately, so totals were calculated e.g. total cane dieback.

At site one, Psa symptom expression was low. For the female and male plots, there were no significant differences between any of the treatments (data not shown).

At site two, Psa symptom expression was high across all treatments. The only variable with a significant difference was leader cankers in September. Treatment one, the standard treatment, had less leader cankers in September, than any other treatment. By October, the number of leader cankers was not significantly different across all treatments.

In this trial, inoculum pressure appears to have been too little at site one and too much at site two, so treatment effects were unable to be identified.

At site one, analysis of the components of yield data showed significant differences on productivity, between treatments. Cane length, number of nodes per cane, bud break and floral bud break per vine were comparable across all treatments.

For treatments one, two and seven, the number of king flowers per cane; and for treatments two and seven, the number of lateral flowers per cane, were significantly less than for treatment eight. The calculated parameters of flowers per metre of cane and flowers per shoot were also significantly less for treatments one, two and seven, than for treatment eight.

The common element in the treatment programmes for treatments one, two and seven is Actigard applied as a foliar spray twice, once immediately after harvest and again at three weeks after first application. Treatments two and seven also included one or two applications of streptomycin with Engulf, respectively. Treatment seven had lower numbers of king and lateral flowers than treatments one and two.

Treatment three, which included Actigard applied only once, three weeks after harvest, had comparable components of yield as for treatment eight (the pre-harvest soil application of Actigard was not applied).

Treatment four, which substituted Ambitious as a foliar application instead of Actigard, had significantly fewer king and total flowers per metre of cane; and treatment five, which was a full copper programme only, had significantly fewer king flowers per metre.

This possible effect of two foliar Actigard applications, once immediately after harvest and again three weeks later, plus streptomycin and Engulf has not previously been reported.

Canopy was considered to be in good condition post harvest, as previously illustrated by Figure 1. Canopy was still in good condition at the time the second applications were made on 16 May 2014. Vines did not appear to be under stress. Frost damage did not occur until 27 May 2014.

2.0 Introduction

This project is an extension of a single trial conducted in 2013/14. In that trial, disease expression was relatively low level, as has generally been observed in Gold 3 over the last two seasons.

However, control vines, which received just two copper sprays over the post-harvest to post-prune period, had significantly more dieback than vines receiving more comprehensive spray protection programmes. There was also a trend (though not significant) for higher disease symptoms in vines that were treated with copper sulphate to advance leaf drop. It was concluded that post-harvest was an important period for Psa protection.

This trial was designed for two sites; a Hort16A site in Nuhaka (or Northern Hawkes Bay), where high Psa infection pressure might be expected, because of known varietal susceptibility; and a Gold 3 site in the Bay of Plenty where the majority of this new variety is now grown.

The trial explores a range of treatments for protection post-harvest and re-visits the comparison of forced versus natural leaf drop.

3.0 Objective

This trial has three objectives.

- To verify the importance of post-harvest spray protection for reducing spring expression of Psa in gold kiwifruit
- To explore options for Psa protection post-harvest in gold kiwifruit
- To further explore the effect of forced leaf drop on the expression of Psa symptoms in the following spring

4.0 Materials and Methods

Treatments
Gold 3 vines at site one and Hort16A vines at site two, received one of eight spray programmes. In addition, at the Gold 3 site, male vines within the Gold 3 block received one of three spray programmes.

Treatments were designed to test for the effects of different components within each of these programmes.

Treated vines received only the treatments outlined below, from the start of the trial until at least three weeks after the post-pruning treatment.

At site one, the pre–harvest soil applied Actigard for treatment three was not able to be applied, because harvest was undertaken earlier than planned, which did not allow the Actigard soil application pre-harvest interval to be satisfied.

The application of copper sulphate planned for leaf fall was voided by a series of three frosts in sequence, on 27-29 May 2014, ranging from -1 to -3^{0}C. The pre-prune applications for all treatments were instead applied immediately post pruning, because winter pruning had already been undertaken.

At site two, the pre–harvest soil applied Actigard for treatment three was applied immediately post-harvest. Other treatments were applied as planned.

Table 1: Treatment Programmes Site One (Gold 3) and Site Two (Hort16A)

Treatment	Pre-Harvest	Immediately Post-harvest	Three Weeks Post-Harvest	Leaf Fall	Late Leaf Fall	Pre-Prune*	Post-Prune
1	-	Actigard (foliar) + Nordox + DuWett	Actigard (foliar) + Nordox + DuWett		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
2	-	Actigard (foliar) + Nordox + DuWett	Actigard (foliar) + Nordox + DuWett		Nordox + DuWett + KeyStrepto + Engulf	Nordox + DuWett	Nordox + DuWett
3	Actigard (soil)	Nordox + DuWett	Actigard (soil; 3wks after first) + Nordox + DuWett		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
4	-	Ambitious (foliar) + Nordox + DuWett	Ambitious (foliar) + Nordox + DuWett		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
5	-	Nordox + DuWett	Nordox + DuWett		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
6	-	No spray	No spray	CuSo4, not done, voided by frost	Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
7	-	Actigard (foliar) + Nordox + DuWett	Actigard (foliar) + Nordox + DuWett		Nordox + DuWett + KeyStrepto + Engulf	Nordox + DuWett + KeyStrepto + Engulf	Nordox + DuWett
8	-	No spray			Nordox + DuWett	Nordox + DuWett	Nordox + DuWett

*Pre-prune treatments were applied post prune at site one

Table 2: Treatments Site One, Male Vines

Treatment	Pre-Harvest	Immediately Post-harvest	Three Weeks Post-Harvest	Leaf Fall	Late Leaf Fall	Pre-Prune*	Post-Prune
1	-	Actigard (foliar) + Nordox + DuWett	Actigard (foliar) + Nordox + DuWett		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
6	-	No spray	No spray	CuSo4, not done	Nordox + DuWett	Nordox + DuWett	Nordox + DuWett
8	-	No spray	No spray		Nordox + DuWett	Nordox + DuWett	Nordox + DuWett

Treatment one was established as the standard programme, using a copper protectant plus an elicitor immediately post harvest, followed by a copper protectant and elicitor three weeks later, followed by a copper protectant at late leaf fall, again at pre prune and again immediately after pruning.

Treatment two as for treatment one except for the addition of Key Strepto and Engulf at late leaf fall timing, to explore any differences in leaf scar protection.

Treatment three added soil applied Actigard before harvest and three weeks post harvest at site two and three weeks post harvest at site one.

Treatment four substituted Ambitious for Actigard in the immediate post harvest and three weeks later spray applications.

Treatment five was a copper programme only, for all post-harvest applications.

Treatment six omitted the two post harvest applications and included copper sulphate during leaf fall, then continued with the standard programme.

Treatment seven added Key Strepto and Engulf at late leaf fall and again before winter pruning (after winter pruning at site one). This treatment showed some potential for reduced Psa symptoms in a previous trial.

Treatment eight was the minimal copper programme, involving no post harvest applications, one application at late leaf fall and one application before and after winter pruning.

At site one male vines received treatments one, six and eight.

At site one, treatment six and eight were effectively the same treatment programmes on both the Gold 3 and male vines, because frosts voided to the application of copper sulphate, which was planned as part of the treatment six programme.

For both treatment two and seven, ACVM permission was obtained to apply Key Strepto with Engulf. Part of the ACVM permission required collection of fruit for residue testing in 2014.

DuWett is a superspreader to enhance spray coverage of picking and leaf scars.

Engulf is a super penetrant surfactant, designed to be used to promote agrichemicals into difficult to penetrate situations. Engulf was selected in this trial as the best option to enhance penetration of Key Strepto into wounds such as leaf scars and pruning wounds.

Sites

Trials were carried out in a Gold 3 orchard in the Te Puke area of the Bay of Plenty region and a Hort16A orchard in Nuhaka, Northern Hawkes Bay. The blocks selected for the trial had vines showing Psa symptoms.

At site one, the Bay of Plenty site, the vines used in the study did not show Psa symptoms at trial commencement.

At site two, the Nuhaka site, the vines used in the study did show some Psa symptoms at trial commencement, but developed significant symptom expression through the winter and spring period. The balance of the block was cut out in winter 2014, with only the canopy in the trial area retained into spring 2014, to allow assessment of Psa symptoms on trial vines

Table 3: Site Information

Site	One	Two
Location	Hill Ridge Orchard Paengaroa KPIN 7046	Riverslea Estate Nuhaka KPIN 3697
Site Details	Middle Block EastPack: Post-harvest entity	Block 5 EastPack: Post-harvest entity
Plants	Conventional Gold 3 Grafted 2010 Full canopy Pergola trained	Conventional Hort16A Mature Full canopy Pergola trained
Spacing	Bays are 3.0m between rows and 6.0m between posts Plots are individual vines two bays wide	Bays are 5.0m between rows and 6.0m between posts, double planted Plots are individual vines two bays wide
Equipment	Solo Mistblower, nozzle setting 3 for Key Strepto +Engulf, Actigard, Ambitious Atom Turbo for Nordox+DuWett	Echo SHR 150 SI motorized knapsack sprayer Cropliner 2000 for Nordox + DuWett

Layout
Each treatment was replicated eighteen times at both sites. Refer **Appendix 1** Trial Layout.

Applications
Harvest was completed by 18 April 2014 at site 1 and 1 April 2014 at site 2.

Winter pruning was undertaken on 20 to 22 July 2013 at site 1 and not undertaken at site 2, due to the owner's intention to cut off the Hort16A canopy and regraft to Gold 3, subsequent to the second spring assessment.

Treatments were applied by HortEvaluation Ltd and Brown Horticulture Ltd at site one and Lewis Wright Valuation & Consultancy Ltd and the orchard owner's staff at site two.

All applications were made in suitable conditions as concentrate sprays at the following rates.

Figure 1: Canopy 2014 at Trial Commencement. Site one (left) and Site two (right)

Table 4: Product Application Rates

Treatment	Immediately Post-harvest		Three weeks Post-harvest		Leaf Fall		Late leaf fall		Pre-prune		Post-prune	
Site 1	22/04/14		15/05/14 Cu	16/05/14			15/06/14 Cu	16/06/14			21/06/14	22/06/14 Cu
Site 2	03/04/14		23/04/14		08/05/14		26/05/14	27/05/14 Cu	16/06/14 Cu	01/07/14	?	
1	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 500ml/ha	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 750ml/ha			Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
2	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 500ml/ha	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 750ml/ha			Nordox + KeyStrepto + Engulf	140g/100L 120g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
3	Nordox + DuWett	140g/100L 500ml/ha	Actigard (soil; 3wks after first) + Nordox + DuWett	200g/ha 140g/100L 750ml/ha			Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
4	Ambitious (foliar) + Nordox + DuWett	150ml/100L 140g/100L 500ml/ha	Ambitious (foliar) + Nordox + Duwett	150ml/100L 140g/100L 750ml/ha			Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
5	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 750ml/ha			Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
6	No spray		No spray		Copper Sulphate	600g/100L	Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
7	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 500ml/ha	Actigard (foliar) + Nordox + DuWett	200g/ha 140g/100L 750ml/ha			Nordox + KeyStrepto + Engulf	140g/100L 120g/100L 750ml/ha	Nordox + KeyStrepto + Engulf	140g/100L 120g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha
8	No spray		No spray				Nordox + DuWett	140g/100L 750ml/ha	Nordox + DuWett	140g/100L 500ml/ha	Nordox + DuWett	140g/100L 500ml/ha
Water L/ha	700. 2x concentrate based on dilute rate of 1400L/ha		700. 2x concentrate based on dilute rate of 1400L/ha, Soil applied Actigard at		2000L/ha		700. 2x concentrate based on dilute rate of 1400L/ha.		500. 2x concentrate based on dilute rate of 1000L/ha			

5.0 Assessments

5.1 Psa

At site one, an assessment was carried out soon after winter pruning was completed, to establish a baseline of Psa symptoms present at that time. At both sites, vines were assessed twice in spring for symptoms of Psa, recording any leaf spot and secondary symptoms such as cane dieback, cane and leader cankers. At each site, contact was maintained with the grower over winter to determine onset of symptom expression.

Assessments were timed to coordinate with the onset of symptom expression and at site one, conducted prior to the removal of infected material.

Symptom expression developed rapidly and to a very significant extent at site two, the Hort16A trial site, by comparison with site one, the Gold 3 trial site. Site two was viewed by the site manager and trial manager on 9 September 2014 and the decision taken to assess the expression of symptoms, guided by the nature and extent of symptoms evident at that time. Assessment was carried out on the permanent vine structure and fruited canopy.

At site one a winter assessment was completed on 3 July 2014, to establish baseline Psa presence. For each Gold 3 plot, number of canes tied and number of dieback shoots or canes was counted. For each male vine plot, number of dieback sites in the structural parts of the vine (trunk and leaders) and number of dieback shoots were counted.

At site one, spring assessments were undertaken on 19 September and 31 October 2014 (just prior to flowering). For each Gold 3 plot, number of ooze sites, number of cankers in trunk rootstock, trunk scion, leader, one year wood and two year wood, number of dieback canes less than 20cm length, more than 20 cm length and number of canes failing to grow, were all counted.

At site one, in addition to the above assessments, for each male plot, number of vines cut off was also recorded, as in some instances, this occurred between the start of the trial and the second spring assessment.

At site two, number of leader cankers and number of canes were counted. Each cane was scored on a scale from zero to five, zero being 0% growth and five being 100% growth, due to Psa dieback effects. These scores are reported as average Psa scores. The proportion of live canopy per vine was also estimated.

5.2 Components of Yield

Component of yield assessments were conducted by AgFirst at the Gold 3 site. The Hort16A site was removed in spring 2014 and was not winter pruned, so components of yield were not conducted at this site.

Return bloom was monitored in spring. Assessments were carried out by AgFirst, doing components of yield bud, shoot and flower counts for five canes on each vine.

5.3 Streptomycin Residues

Fruitlet samples were collected from cropping Gold 3 vines receiving streptomycin treatments and sent to Hill Laboratories for residue testing. Samples were collected approximately on 12 December 2014, 21 days after fruit set.

This requirement was met as part of the Ministry of Primary Industries permission to apply streptomycin outside of the current permitted use period. The grower did not apply streptomycin as part of the orchards spray programme during spring 2014, so the samples were collected. Samples were collected from treatment 2, collecting a pooled 40 fruit sample.

5.3 Metabolites

Leaf samples were collected from the Gold 3 site on 2 May 2014, ten days after first post-harvest applications, then stored in a -80°C freezer for later metabolite analysis, if treatment effects were found.

Four vines were sampled for each of treatments one, four, five and eight, collecting one sample per vine, comprising of three leaves per sample.

The samples allow for later analysis of the effects of Actigard (treatment one), Ambitious (treatment four), versus the copper-only programme (treatment five) versus no application (treatment eight), on vine metabolite profiles.

5.4 Weather Data

For site one, the Gold 3 site, weather data recorded at the nearby Harvest.com sites Haywood and O'Neill, both within about 0.7km of the trial site and for site two, the Hort16A site, weather data recorded at the nearest site, NIWA Mahia, within about 22km from the trial site, were referred to.

At site 1, 87mm rain fell on ten days between the end of harvest on 20 April and three weeks later. By late leaf fall in mid-June, 302mm rain fell on another ten days, of which 275mm fell in the week 9 - 15 June 2014. Pruning was completed in a few days of dry weather 19-21 June 2014.

From the post pruning period to bud break, about 240mm rain fell on 31 days, about typical for the region.

As previously mentioned, application of copper sulphate to hasten leaf fall was voided by the occurrence of three sequential frosts on 27-29 May 2014. Air temperature minima ranged from -1 to -3^{0}C and ground temperature minima ranged from -2 to -5.4^{0}C. These frosts resulted in the latter part of leaf fall occurring in a short, dry period, followed by a very wet period at the end of leaf fall.

Figure 2: Site 1 Leaf Fall 28 May 2014

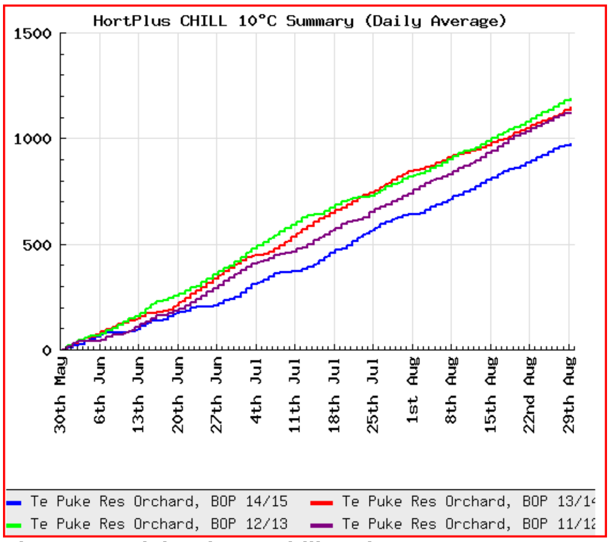


Figure 3: Richardson Chill Units 30 May – 31 August 2014

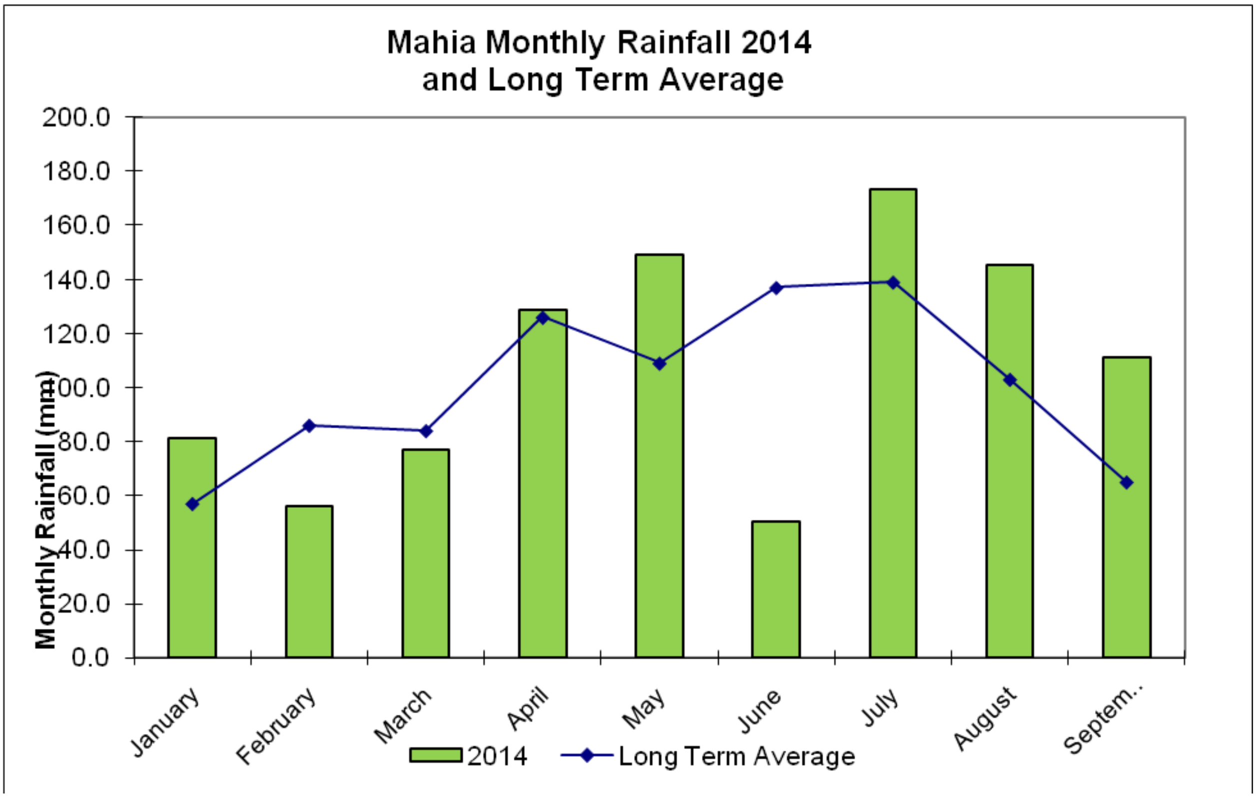
Winter conditions were warmer than average as indicated by the lower winter chill units calculated for Te Puke Research Station in 2014.

For site two, weather data records were reviewed for the nearest site at Mahia. Leaf fall was largely complete by the end of May 2014, during which time about 150mm rain fell on 17 days, with half of this occurring on 30 May at the end of leaf fall. In June 2014, rainfall was much lower than the long term average.

Site two was not conventionally pruned, due to the intention to cut off the Hort16A canopy at the end of pruning. This means that pruning wound exposure did not occur.

Therefore, infections which resulted in spring symptom expression would have occurred through other infection pathways than pruning wounds.

Given the very rapid and typical rate and extent of symptom progress in spring 2014, it is likely that infection could have been occurring in the late autumn as well as through winter 2014.



5.5 Data Analysis

All Gold 3 trial block plot data were analysed as a split plot analysis i.e. plots within big plots, with a plot being a single vine and a big plot being where a treatment was applied to six vines in the same area. Data were square root transformed to normalise the variability.

Many variables had too many zeroes to be analysed separately totals were calculated e.g. total cane dieback and total ooze plus dieback.

For the components of yield data, data for each set of five canes per vine was averaged before analysis. Variables were square root transformation to normalise the variability.

All Hort16A trial block plot data were analysed using Analysis of Variance. A square root transformation of the variables was undertaken as some variables required this to normalise the variability. Plot four was omitted from the analysis as it was an outlier.

6.0 Results

6.1 Psa

Site 1

At site one, symptom expression was low. There was a very minor amount of dieback cane present prior to winter pruning. The number of dieback canes increased from first to second assessment.

For the female and male plots, there were no significant differences between any of the treatments (data not shown).

Site 2

At site two, symptom expression was high across all treatments.

The only variable with a significant difference was leader cankers in September. Treatment one, the standard treatment, had less leader cankers in September, than any other treatment.

By October, the number of leader cankers was not significantly different across all treatments.

All the variables with no highlighted treatments had no significant differences compared with treatment eight.

Table 5: Psa Symptoms and Treatments Site 2

PSA symptoms	res df	Treatment								Trt sed	Trt LSD 5%	Trt Fprob	Sqrt Trt Fprob
		1	2	3	4	5	6	7	8				
		green; significantly lower than treatment 8											
Leader Cankers September	118	2.1	2.7	3.2	4.1	3.7	4.0	2.9	3.9	0.73	1.44	0.061	0.044
% Live Canopy September	118	50.6	43.8	46.0	39.0	42.1	45.3	53.2	42.6	7.50	14.85	0.623	0.628
No. Canes September	118	12.8	15.1	13.4	13.8	15.4	14.5	14.2	14.1	1.20	2.37	0.412	0.377
Average PSA score September	118	2.8	2.6	2.7	2.2	2.3	2.4	2.7	2.3	0.35	0.69	0.635	0.895
% Fully dead canes September	118	26.8	25.5	30.2	32.6	31.3	32.9	28.8	30.5	7.03	13.92	0.961	0.845
Leader Cankers October	118	2.6	2.4	3.0	3.7	4.2	3.7	2.8	3.4	0.72	1.43	0.190	0.097
% Live Canopy October	118	31.9	34.1	35.8	26.4	29.8	27.8	36.9	28.3	6.32	12.52	0.613	0.734
No. Canes October	118	12.8	14.6	12.4	13.4	15.1	14.4	13.3	14.1	1.18	2.33	0.287	0.267
Average PSA score October	118	2.1	2.2	2.1	1.8	1.8	1.7	2.2	1.6	0.31	0.61	0.314	0.389
% Fully dead canes October	118	38.5	40.4	39.6	50.4	45.4	46.4	38.3	49.4	7.26	14.38	0.492	0.451

6.2 Growth – Site One Only

There were significant differences between treatments as shown in Table 6. Treatment eight was the untreated control. Treatments highlighted in green were significantly lower than treatment eight.

Table 6: Components of Yields and Treatments Site One

Components of Yield	res df	Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt sed	Trt LSD 5%	Trt Fprob
	treatments highlighted green are significantly lower than treatment eight											
Nodes/Metre	14	14.2	14.4	15.1	14.5	14.6	15.2	15.0	15.2	0.37	0.80	0.071
King flowers/Metre	14	29.4	28.0	34.3	29.4	30.0	34.9	24.4	35.2	2.29	4.92	0.003
All flowers/Metre	14	35.9	32.2	46.3	37.5	39.1	44.3	28.1	46.6	3.90	8.36	0.002
%Bud break	14	61.9	62.1	60.5	56.6	56.9	58.7	55.7	59.1	2.74	5.88	0.232
%Fruitful bud break	14	52.5	52.9	53.9	48.7	48.7	52.9	47.0	53.2	2.81	6.03	0.175
%Nonfruitful bud break	14	9.4	9.2	6.5	7.9	8.2	5.8	8.7	5.8	1.71	3.68	0.269
King flowers/Bud	14	2.1	2.0	2.3	2.0	2.1	2.3	1.7	2.4	0.16	0.34	0.010
Flowers/Bud	14	2.6	2.3	3.1	2.6	2.7	3.0	1.9	3.1	0.27	0.57	0.005
Blind shoots	14	2.4	2.8	2.1	2.6	2.6	1.6	2.5	1.7	0.54	1.16	0.311
Dormant	14	10.7	11.8	12.5	14.5	14.1	11.7	14.6	12.9	1.27	2.72	0.057
Cane length	14	2.0	2.2	2.1	2.3	2.2	1.9	2.1	2.1	0.16	0.35	0.373
Nodes	14	27.4	30.6	31.1	33.0	31.6	28.1	31.7	31.1	1.91	4.10	0.140
Shoots	14	16.8	18.8	18.6	18.4	17.6	16.4	17.0	18.2	1.22	2.62	0.393
King Flowers	14	58.0	59.4	70.8	66.1	64.0	65.6	51.4	73.4	5.62	12.05	0.031
Lateral Flowers	14	14.1	9.3	26.3	18.4	20.0	18.1	8.2	25.3	5.41	11.60	0.036
King and lateral flowers	14	72.1	68.7	97.0	84.5	84.0	83.7	59.6	98.7	10.33	22.16	0.023
Side flowers/Metre	14	7.3	4.7	12.7	9.1	9.7	9.8	4.2	12.2	2.17	4.65	0.012
Avg king flowers/Shoot	14	3.4	3.2	3.8	3.6	3.6	4.0	3.0	4.0	0.23	0.48	0.004
Avg side flowers/Shoot	14	0.8	0.6	1.5	1.1	1.1	1.2	0.5	1.4	0.24	0.52	0.010
Avg total flowers/Shoot	14	4.2	3.7	5.2	4.6	4.7	5.2	3.4	5.3	0.43	0.92	0.003

7.0 Discussion

At site one, natural inoculum pressure was sufficient for Psa disease symptoms to be expressed, although not sufficient to obtain a high level of symptom expression and consequently identify significant differences in treatment effects.

The lack of expression of sufficient symptoms to separate treatment effects continues to frustrate the understanding of best options for autumn and winter protection from Psa.

The number of cankers and ooze sites per vine decreased from first to second assessment, which can be partly explained by the removal of some symptomatic material after first spring assessment.

However, it was also evident at the second spring assessment, just prior to flowering, that some cankers had stopped progressing, and had either become inactive or the vine had produced callus tissue around the cankers. These “healed” cankers were not counted as active symptoms of Psa.

Treatment two consistently had the least number of symptoms for both assessments and all symptoms assessed, although this difference in the lesser number of symptoms was not significant.

For the male vines, in the first spring assessment, treatment one reduced the effects of Psa by comparison with no Psa product application between post-harvest and late leaf fall although this difference was again not significant.

At site two, natural inoculum pressure was so high that treatments appeared to be overwhelmed by Psa on Hort16A. Despite the high level of symptom expression, we were not able to deduce any treatment effects.

At this orchard Psa symptoms progressed very rapidly in spring with a decrease in percentage live canopy from approximately 39-51% to 26-37%, over a three week period, across all treatments.

There was a trend that treatment programmes including full copper protectant (treatment 1), foliar applied elicitors and Key Strepto (treatments 2, 3 and 7), reduced the effects of Psa by comparison with other treatment programmes, although these differences were not significant.
.
The components of yield results showed that there were treatment effects on productivity. These productivity measures were undertaken on five healthy canes per vine, at the time of counting.

There were no differences between treatments for cane length, number of nodes per cane, bud break and floral bud break per vine. In other words, the canes, buds and bud break were comparable across all treatments.

However, there was a significant difference in the floralness of bud break.

For treatments one, two and seven, the number of king flowers per cane; and for treatments two and seven, the number of lateral flowers per cane, were significantly less than for treatment eight. The calculated parameters of flowers per metre of cane and flowers per shoot were also significantly less for treatments one, two and seven, than for treatment eight. Treatment seven had the lowest floralness.

The common element in the treatment programmes for treatments one, two and seven is Actigard applied as a foliar spray twice, once immediately after harvest and again at three weeks after first application, with the additional common element for treatments two and seven being the addition of one or two applications of streptomycin with engulf respectively.

Treatment three, which included Actigard applied only once, three weeks after harvest, had comparable components of yield as for treatment eight (the pre-harvest soil application of Actigard was not applied).

Treatment four, which substituted Ambitious as a foliar application instead of Actigard, had significantly fewer king and total flowers per metre of cane; and treatment five, which was a full copper programme only, had significantly fewer king flowers per metre.

This possible effect of two foliar Actigard applications, once immediately after harvest and again three weeks later, plus streptomycin and Engulf has not previously been reported.

Canopy was considered to be in good condition post harvest, as previously illustrated by Figure 1. Canopy was still in good condition at the time the second applications were made on 16 May 2014. Vines did not appear to be under stress. Frost damage did not occur until 2-29 May 2014.

The reduction in yield, as determined by components of yield, appears to be associated with the more intensive spray programmes which included actigard and streptomycin plus engulf, in addition to copper sprays, on what was a healthy and still functional canopy.

Figure 3: Site One Canopy 16 May 2014

The trial shows the challenge of relying on the real distribution of Psa on the vines we used because of the unknown and difficult to quantify nature of inoculum distribution. The trial also highlights the challenge of fine tuning a spray programme to control Psa without compromising orchard productivity.

Reliance on natural infection periods to test the relative efficacy of different treatments at different times is also challenging as conditions may or may not prevail at times treatments are applied, to actually test efficacy.

In this trial, inoculum pressure appears to have been too little at site one and too much at site two.

8.0 Acknowledgements

The authors would particularly like to thank the growers who allowed us to undertake trials at their properties.

- Site one – Cameron and Tammy Hill
- Site two – Michael Montgomery

Appendix 1: Trial Layout

Site 1

											1		106,1		1	7	72,7		69,7	-	36,5	-	35,5	-	-	o
	144,4		1	4	141,4		x		1	1	108,1		105,1	2	x	-	71,7	-	68,7		-	5	34,5		32,5	
	143,4	-	142,4	-	140,4	o	139,4	2	x	-	107,1		104,1		1		70,7		67,7	-	-	-	33,5	-	31,5	o
			138,1		x		135,1		-		1	-	103,1	o	x	o	1	2	1		-		29,7		27,7	
		-	x	1	x	o	134,1	M39,8	1		1		1		1	4	65,4		63,4	o	-	-	-	o	26,7	o
			137,1		136,1		133,1		1	8	1	-	x	o	66,4	-	x	-	62,4		30,7	7	28,7		25,7	
			132,3	-	x	M54,1		M38,8	1	-	1		1		x		64,4		61,4	o		o	x	o	x	o
			131,3	3	129,3		127,3		-		-	o	99,8	o	-	-	x	2	x		x	3	22,3		20,3	
		-	-	M53,1	-	-	-	M37,8	x	M35,8	x		-		60,5	5	x		57,5	o	24,3	o	x	o	19,3	o
			130,3		128,3		x		102,8		101,8	M34,8	98,8	o	59,5	-	58,5	-	56,5		23,3		21,3		x	
	126,5	-	124,5	-	123,5	o	-	M36,8	1	o	100,8		97,8		x	-	-		55,5	M40,1	1	o	17,2	o	15,2	o
	125,5		-	5	122,5		121,5		x		96,6	M28,6	1	o	1	M19,1	52,2	M15,1	1		-	2	x		x	
M52,8	1	o	-	o	1	o	1	-	-	M31,6	95,6		1		54,2	2	51,2		1	o	18,2	o	o	o	14,2	o
	-		120,8	8	117,8		1		1	6	94,6	o	1	M22,1	x	M18,1	50,2	M14,1	1		x		16,2		13,2	
M51,8	1	-	119,8	M49,8	116,8	M48,8	1	M33,6	1	M30,6	93,6		-		53,2		49,2		-	2	12,4	2	x	o	x	o
	1		118,8		1		1	-	-	-	92,6	-		M21,1	48,3	M17,1	45,3	-	1		11,4	4	x		9,4	
M50,8	1	-	1	-	115,8	M47,8	-	M32,6	x	M29,6	91,6		1		47,3	3	44,3		1	o	x	o	10,4	o	8,4	o
	1		114,6		111,6		1		90,2	2	88,2	-	86,2	M20,1	46,3	M16,1	43,3	M13,1	1		x		x		7,4	
M46,6	113,6	M45,6		M44,6	110,6	M42,6	1	M27,1	89,2	M25,1	87,2		85,2		1		40,8		1	M6,6	1	M4,6	1	o	1	o
	1		112,6	6	109,6		1		84,7	7	82,7		80,7	M12,8	42,8	M10,8	39,8	M8,8	1		4,6	6	5,6		6,6	
				M43,6	-	M41,6	1	M26,1	83,7	M24,1	81,7		79,7		-	8	38,8		1	M5,6	3,6	M3,6	2,6	M2,6	1,6	M1,6
					1		1		78,1	1	76,1	M23,1	74,1	M11,8	41,8	M9,8	37,8	M7,8	x		x		x		x	
								o	77,1		75,1		73,1													

mature female		1
young female		x
young male		o
missing		-
1,1 etc	female plots	
1,1 etc	male plots	

Site 2

		Lombardy Poplar Shelter									
Lombardy Poplar Shelter		Plot	Trt	Plot	Trt	Plot	Trt	Plot	Trt	Plot	Trt
		1	7	33	5	65	2	97	8	129	6
		2	2	34	8	66	3	98	6	130	2
		3	5	35	6	67	6	99	4	131	7
		4	8	36	4	68	5	100	2	132	4
		5	6	37	7	69	7	101	7	133	3
		6	1	38	1	70	4	102	5	134	1
		7	3	39	3	71	8	103	3	135	5
		8	4	40	2	72	1	104	1	136	8
		9	1	41	4	73	7	105	3	137	2
		10	2	42	2	74	4	106	7	138	4
		11	3	43	3	75	2	107	5	139	7
		12	4	44	6	76	1	108	2	140	3
		13	6	45	8	77	8	109	8	141	6
		14	7	46	1	78	6	110	1	142	8
		15	8	47	5	79	3	111	4	143	5
		16	5	48	7	80	5	112	6	144	1
		17	4	49	3	81	4	113	1		
		18	3	50	2	82	2	114	4		
		19	2	51	7	83	5	115	5		
		20	1	52	6	84	7	116	6		
		21	5	53	8	85	1	117	8		
		22	7	54	1	86	6	118	2		
		23	8	55	5	87	3	119	7		
		24	6	56	4	88	8	120	3		
		25	1	57	5	89	7	121	3		
		26	4	58	2	90	2	122	2		
		27	7	59	3	91	4	123	7		
		28	6	60	1	92	5	124	5		
		29	8	61	8	93	8	125	4		
		30	2	62	6	94	1	126	8		
		31	3	63	4	95	6	127	1		
		32	5	64	7	96	3	128	6		
		125	4	127	1						
		126	8	128	6						
		Pinus radiata shelter									