



2018 Potted Plant Field Trial Report

Efficacy of tank mixes on Psa control in Hayward and Gold3 Potted Plants

2016 - 2018



May 2018

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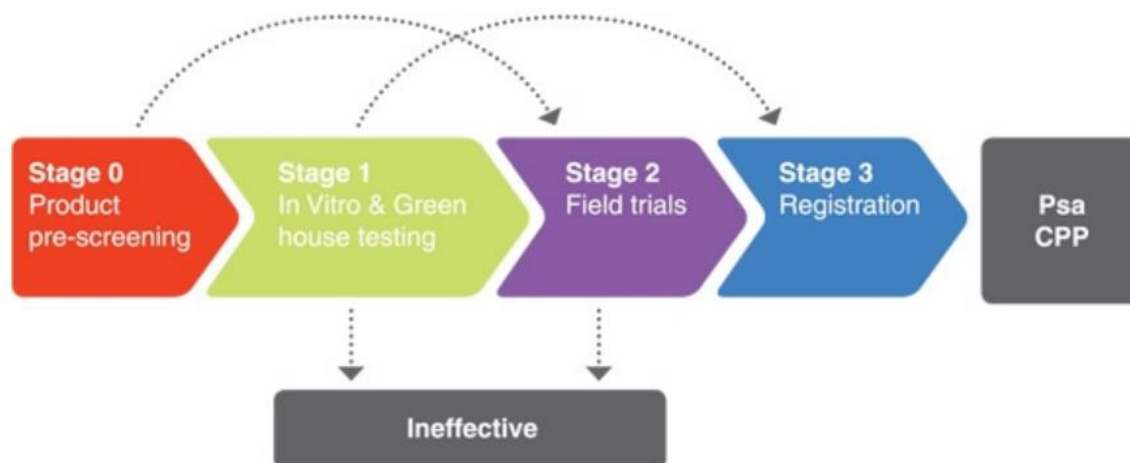
Introduction

Zespri, with support from KVH, is coordinating the screening of the effectiveness of a wide range of products to control *Pseudomonas syringae* pv. *actinidiae* (Psa-V). The screening programme has been developed to identify options for managing Psa-V. To understand the steps in the product testing programme the process is outlined in the diagram below.

An important stage in the testing programme is field testing which is the subject of this report. The efficacy of products for the control of Psa-V is being evaluated using potted plants in an infected orchard in Paengaroa. The plants have been propagated Psa-V free and typically are treated with products prior to being shifted to the Paengaroa region where they are actively inoculated with Psa-V. Symptoms are subsequently monitored in the field. Products are applied using protocols agreed with the suppliers.

Zespri has contracted HortEvaluation Ltd to undertake these field trials. The results are reported directly to Zespri so that publications of this nature can be produced.

This report documents the findings from a trial conducted from 2016 to 2018 on Gold3 and Hayward potted plants in which a range of products were tank mixed, with Actigard and Kocide Opti as the positive controls.



Objective(s)

This trial was established to determine the effect of different tank mixes (two products maximum) of Psa control products (Actigard, Nordox, Kocide Opti, Ambitious and Streptomycin) with other pest and disease control products (Proclaim, Movento, Luna Privilege) on Psa control and phytotoxicity, using Gold3 and Hayward potted plants. The tank mix combinations were decided using spray diary information which indicated that these mixes were recorded for 5% or more of the spray applications.

Methodology

All spraying, inoculating, transportation and disposal of plants was performed under the relevant MPI / ACVM and KVH approvals. All products were tested with the permission and guidance of the suppliers.

Plants

This trial utilised Gold3 and Hayward on Bruno rootstock kiwifruit potted plants. The Gold3 plants were sourced from Waimea Nursery, Nelson, which is in a Psa exclusion zone. The Hayward plants were sourced from a KPCS fully certified kiwifruit nursery in the Bay of Plenty region. The plants were believed to be Psa-V free at the start of the trial as there were no observed symptoms of Psa-V disease. The plants were propagated and held under cover at the Bay of Plenty nursery, then randomly assorted into treatment groups and labelled by HortEvaluation Ltd, prior to the start of the trial.

Treatments

There were 13 treatment groups for the Gold3 potted plants, and 10 treatment groups for Hayward potted plants, with 15 plant and 14 replications per group respectively. There were less treatments for the Hayward trial, as the proposed streptomycin treatments were removed once streptomycin was removed from the CPS. The Gold3 trial was conducted in 2016, whilst the Hayward trial was completed in 2018. The delay for the Hayward trial was due to a lack of suitable Hayward potted plants for trial purposes. Tables 1a and 1b list the treatment groups, active ingredient, amount of active ingredient, rate of product application, and the timing of applications relative to Psa inoculation. Actigard treatments were applied seven days before Psa inoculation.

Table 1a. Gold3 potted plant treatment list

Treatment	Active Ingredient	Rate (per 100L water)	Application timing (days)
Actigard + Kocide Opti	Acibenzolar-S-methyl + copper hydroxide	20g/70g	-7
KeyStrepto + Kocide Opti	Streptomycin + copper hydroxide	60g/70g	-1
Actigard + Nordox	Acibenzolar-S-methyl + cuprous oxide	20g/37.5g	-7
Kocide Opti + Proclaim	Copper hydroxide + emamectin benzoate	70g/2g	-1
Ambitious 10SL + Kocide Opti	Forchlorfenuron + copper hydroxide	50ml/70g	-7
Actigard + Movento 100SC	Acibenzolar-S-methyl + spirotetramat	20g/96ml	-7
Kocide Opti + Luna Privilege	Copper hydroxide + fluopyram	70g/30ml	-1
KeyStrepto+ Nordox	Streptomycin + cuprous oxide	60g/37.5g	-1
KeyStrepto	Streptomycin	60g	-1
Kocide Opti	Copper hydroxide	70g	-1
Actigard	Acibenzolar-S-methyl	20g	-7
Water	N/A	N/A	N/A
Psa	N/A	N/A	N/A

-7 = 7 days before Psa inoculation, -1 = 1 day before Psa inoculation. N/A = none applied

Table 2b. Hayward potted plant treatment list

Treatment	Active Ingredient	Rate (per 100L water)	Application timing (days)
Actigard + Kocide Opti	Acibenzolar-S-methyl + copper hydroxide	20g/70g	-8
Actigard + Nordox	Acibenzolar-S-methyl + cuprous oxide	20g/37.5g	-8
Kocide Opti + Proclaim	Copper hydroxide + emamectin benzoate	70g/2g	-1
Ambitious 10SL + Kocide Opti	Forchlorfenuron + copper hydroxide	50ml/70g	-8
Actigard + Movento 100SC	Acibenzolar-S-methyl + spirotetramat	20g/96ml	-8
Kocide Opti + Luna Privilege	Copper hydroxide + fluopyram	70g/30ml	-1
Kocide Opti	Copper hydroxide	70g	-1
Actigard	Acibenzolar-S-methyl	20g	-8
Water	N/A	N/A	N/A
Psa	N/A	N/A	N/A

-8 = 8 days before Psa inoculation, -7 = 7 days before Psa inoculation, -1 = 1 day before Psa inoculation. N/A = none applied

Treatment application

Spraying of control products as tank mixes was performed at the nursery site in the Bay of Plenty. A gas assisted backpack sprayer was used to produce fine droplets. The entire canopy of each plant was thoroughly sprayed.

Plants were inoculated for Gold3 on 2nd February 2016 and for Hayward on 13th February 2018. On the day of inoculation, the plants were transported to the trial site at 232 Billing Road, Pukehina. The plants were placed inside a gazebo, to ensure containment of inoculum at time of application.

Inoculum was cultured by Plant and Food Research, Te Puke to a concentration of 10^8 cfu/ml bacterium. A sample of the inoculum was taken at the beginning and end of plant inoculation to monitor the concentration of bacteria. The inoculum concentration remained at 10^8 cfu/ml throughout the procedure.

Plants were inoculated in groups, with plants being randomly chosen from each treatment group to be inoculated at any one time, to account for any variation in inoculation that may have occurred throughout the day.

The inoculum was sprayed onto the undersides of the leaves until wet, with 5L hand-held pressure sprayers with fine nozzles. The water treatment group was sprayed in an identical manner with tap water.

Initial wetting of plants

Once inoculated the plants were placed under overhead water misters for 48 hours with continuous water flow, to ensure the wet climatic conditions required for disease incidence. After 48 hours of misting, the plants were relocated to their final randomised trial site positions. The plants were watered twice a day, for 2 hours, via drippers placed over their pots.

Assessments

The level of leaf spotting, as a percentage of total leaf area covered in spots were visually estimated and recorded for Gold3 at days 15, 22, 29 and 43 post inoculation, and for Hayward at days 9, 15, 22 and 34. The same assessors were used to score the plant disease symptoms, to ensure continuity in the scoring. Assessments were performed during February and March for both trials. Only a low percentage of secondary symptoms and phytotoxicity were observed during this trial, hence no analysis of these data has been undertaken and no results are reported.

While visual assessments are subjective, the same assessor performed each assessment to ensure consistency of scoring. Throughout treatment application, inoculation and assessment, the focus was on ensuring consistency across treatments.

Weather

Gold3 2016

On 26 January 2016, when the elicitor treatment mixes were applied in Hamilton, the maximum temperature reached 31.9°C. Conditions were dry from then until 31 January 2016, when 33mm rain fell, followed by 7mm rain on 1 February 2016. However all plants were moved under a protective canopy to keep them dry, prior to the start of rain on 31 January. Plants due for

treatment with protectant mixes or standards on 1 February 2016 were treated under cover. Relative humidity from 26 January to 1 February 2016 was on average 84%.

Conditions during inoculation and initial wetting were dry with a maximum temperature of 27°C.

After the initial wetting and for the 43 day duration over which plants developed symptoms and were assessed, there were 13 rain days with a total of 125.2mm rain recorded. Average daily temperature during the trial was 19.2°C and average relative humidity was 86.5%.

Hayward 2018

Weather Conditions after Inoculation

Plants were kept covered in a greenhouse environment in Te Puke prior to and after treatment applications dried. Whilst plants were kept under cover during the period between application of treatments and inoculation, conditions outside the greenhouse were wet. Rainfall of 120.2mm was recorded from 5-12 February 2018, with 116.4mm of this rain falling from 9-11 February 2018.

On the day of inoculation, rain fell (6.8mm) and further rain fell (13.2mm) during the 48 hour wetting period when plants were held under overhead misters post-inoculation.

After the initial wetting and for the 34 days duration over which plants developed symptoms and were assessed, there were 7 rain days and 62.6mm rain fell, with 40mm on 12 March 2018.

Average daily temperature was 19.3°C. Relative humidity averaged 77% over the assessment period.

Statistical Analysis

Analysis of the leaf spotting data and secondary symptoms was performed in JMP 13 Statistical Package (SAS Institute). An ANOVA was performed comparing all of the treatment groups at the different assessment times. If a significant difference was indicated, further analysis was performed using a Tukey-Kramer test to determine the differences between each treatment versus Psa alone at each assessment.

Results and Interpretation

2016 Gold3 Trial

There was a low level of leaf spotting in this trial, with the Psa treatment group displaying an average leaf spot of 6% at the end of the trial. The water treatment group had less than 2% leaf spotting at the end of the trial. Figure 1 shows the leaf spotting data for the Gold3 potted plants.

There were no significant differences in leaf spot between the different treatment groups at any of the assessments. This lack of significance may be due to the low level of leaf spotting. However, no treatment combination resulted in worse symptoms than the Psa only positive control.

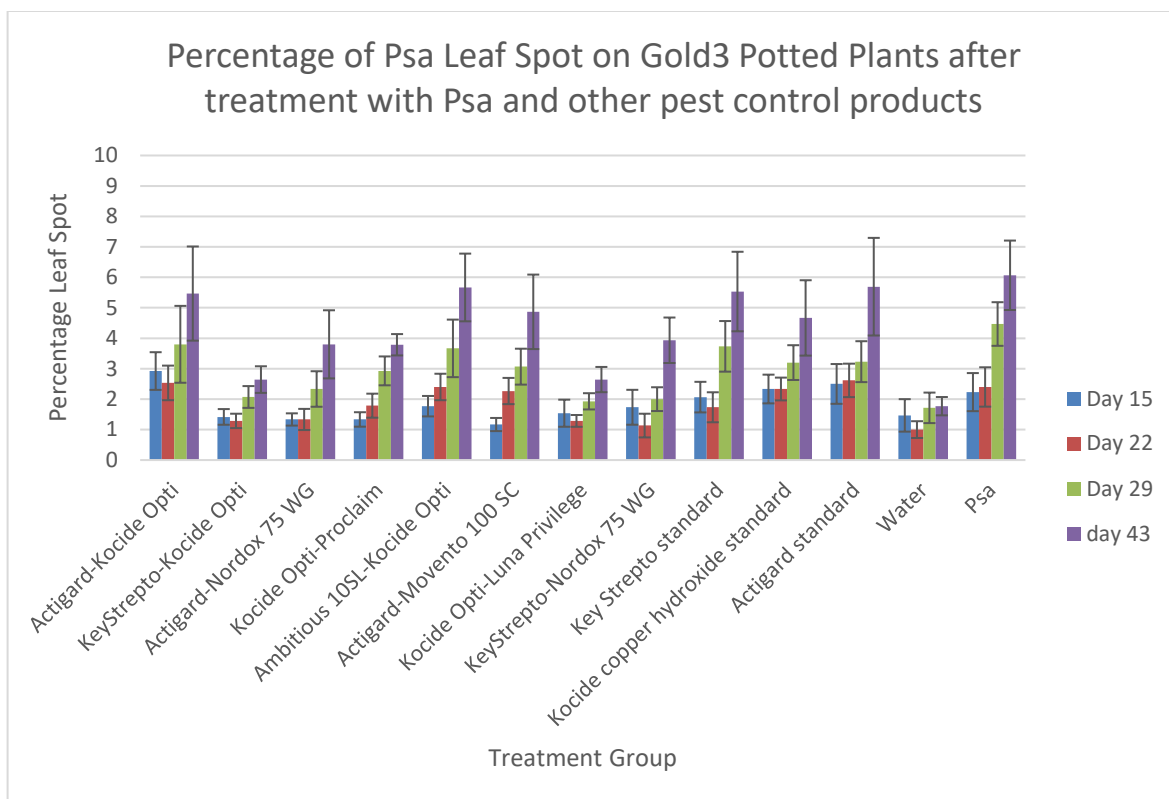


Figure1. Percentage of leaf spot on Gold3 potted plants (2016). Error bars are +/- SEM.

2018 Hayward Trial

There was a high level of leaf spotting in this trial, with the Psa treatment group displaying an average leaf spot of over 50% at the end of the trial. The water treatment group had 5% leaf spotting at the end of the trial. Figure 2 shows the leaf spotting data for the Hayward potted plants.

All treatment groups, along with the water control, had significantly less leaf spot throughout the trial, suggesting that the tank mixing of the combinations tested in this trial did not have an impact on the efficacy of the Psa control products (Actigard, Ambitious, Nordox and Kocide). However, the water control, Actigard + Nordox and Actigard + Movento treatments also had significantly less leaf spot than the Kocide + Proclaim and Kocide + Luna Privilege treatments throughout the first three assessments (22 days). At the final assessment only Actigard + Nordox and Ambitious + Kocide had the same level of significance as the water negative control, suggesting that these tank mix combinations offered the best Psa control.

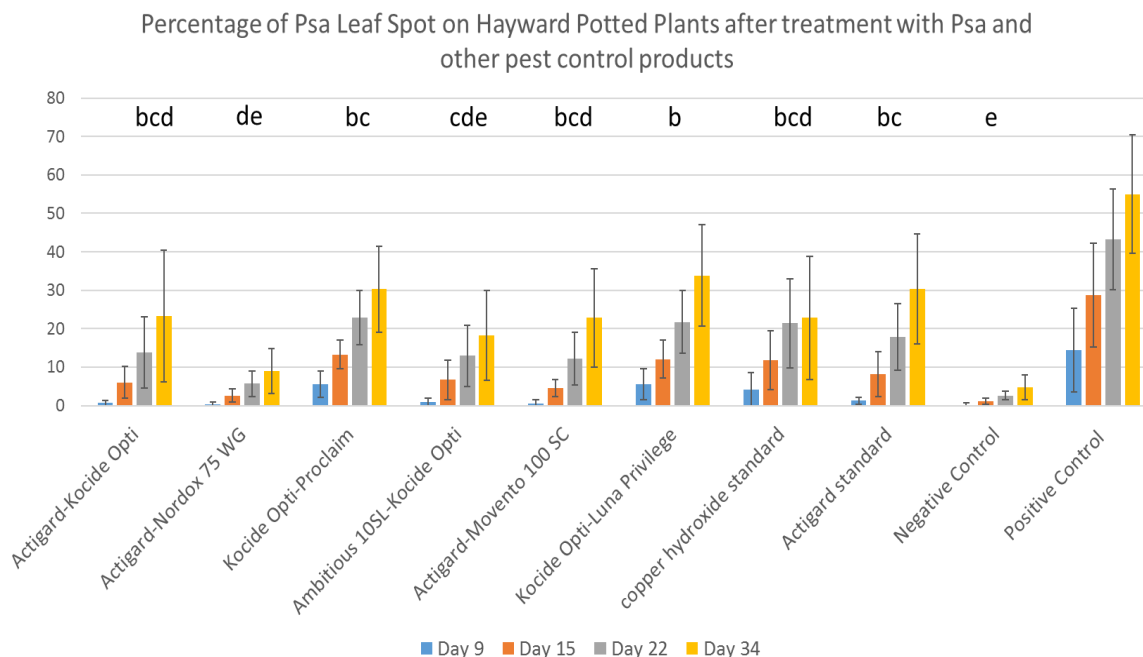


Figure 2. Percentage of leaf spot on Hayward potted plants (2018). Error bars are +/- SEM. Letters denote significant difference between the treatments at the final assessment (day 34 post Psa inoculation), Positive control = a.

Summary

Spray inoculation of Gold3 plants with 10^8 cfu/ml of Psa-V resulted in a low level of infection, and a high level in Hayward plants, as determined by leaf spot analysis. Typically, mature Gold3 on orchards does not show leaf spot to any great degree, so the degree of leaf spotting observed in this trial could be a reflection of the greater level of Psa tolerance in Gold3, or the fact it doesn't spot as much as Hayward..

A number of observations and suggestions can be made from the data:

1. In both trials, the tank mixes (two mix combinations) did not affect the efficacy of the Psa control products. However, in Hayward mixing Actigard with Nordox, or Ambitious with Kocide Opti resulted in the best protection for up to 34 days.
2. Ambitious is not recommended for use on Gold3 plants, but was tested in this trial for completeness.
3. In the Hayward trial, the combination of Kocide + Proclaim and Kocide + Luna Privilege still significantly reduced leaf spot, but this was not as effective as the Actigard + Nordox, or Ambitious + Kocide Opti. It should be noted that plants from these treatment groups (Kocide + Proclaim and Kocide + Luna Privilege) were generally observed to have more severe leaf spotting, with some plants comparable to the Psa positive control (Figure 3a-c), to suggest some caution around these combinations. It is suggested that these mixes are investigated further on an on-orchard trial.



Fig 3a



Fig 3b



Fig 3c

Figure 3 a – c. All photos taken at final assessment (34 days post Psa inoculation) a = Kocide + Proclaim; B = Kocide + Luna Privilege; c = Psa positive control.

4. Further work is recommended using three or more combination tank mixes on efficacy of Psa, pest or disease control in both Gold3 and Hayward plants.

Spray Compatibility Part 2

A parallel project was undertaken to investigate the impact of common tank mixes on pest and disease control, other than Psa. Combinations of two or more products were determined by spray diary information that showed a greater than 5% usage within the industry, (McKenna et al, 2017).

For the Psa mixes Kocide Opti or Actigard were combined as follows:

Kocide + Proclaim

Kocide Opti + Prodigy (methoxyfenozide)

Kocide Opti + Prodigy + Luna Privilege

Kocide Opti + Prodigy + Luna Privilege + Actigard

None of the tank mixes showed reduced efficacy of the pest or disease control targeted. Prodigy (Brown Headed Leaf Roller), Luna Privilege (sclerotinia), Kocide Opti (Psa) and Actigard (Psa) were found to be compatible, as tank mixing of these products did not affect the efficacy of Prodigy against neonate Brown Headed Leaf Roller larvae or Luna Privilege against Sclerotinia.

There may have been a positive interaction between Proclaim (Brown Headed Leaf Roller) and Kocide Opti that prolonged the residual life of Proclaim. This shows an interesting contrast to the Psa trial discussed in this report, where mixing of Kocide Opti and Proclaim led to the observation of generally worse leaf spotting, and again suggests further research into this combination should be considered.

References

McKenna C, Parry B, Dobson S, Rogers P, Stannard K, Shahjahan K, Davy M, Hoyte S (2017) The compatibility of pesticides applied to kiwifruit before flowering (CP1694). Client report for Zespri.