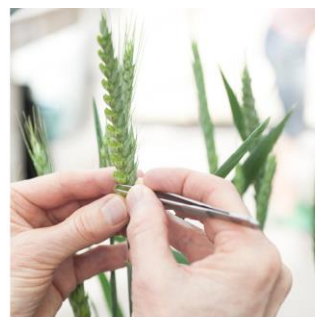


PFR SPTS No. 17051

VI1861: Fruit quality attributes for 'Hayward' and Gold3 kiwifruit treated with Aureo[®] Gold during flowering and fruit set 2017/18

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October 2018



Confidential report for:

Zespri Group
V11861

Zespri information:

Milestone No.	V11861-30-E
Contract No.	V11861
Project Name:	Storage effects of Aureo Gold 2017/18

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PUBLICATION DATA

Hoyte S, Elmer P, Parry F, Phipps J, Rees J, Lyall K, Wallace J, Alavi M. October 2018. V11861: Fruit quality attributes for 'Hayward' and Gold3 kiwifruit treated with Aureo® Gold during flowering and fruit set 2017/18. A Plant & Food Research report prepared for: Zespri Group. Milestone No. 77652. Contract No. 35447. Job code: P/310113/02. SPTS No. 17051.

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EXECUTIVE SUMMARY

VI1861: Fruit quality attributes for 'Hayward' and Gold3 kiwifruit treated with Aureo® Gold during flowering and fruit set 2017/18

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October 2018

Background

The New Zealand Institute for Plant and Food Research Limited have developed a new yeast-based biological control agent (YBCA5, to be registered under the trade name Aureo® Gold) that has activity against bacterial canker of kiwifruit, caused by *Pseudomonas syringae* pv. *actinidiae* (Psa). In order to provide reassurance that spray application of YBCA5 to kiwifruit does not adversely affect fruit set or the physical appearance of harvested kiwifruit, spray trials were established in several orchards during the 2017–18 season.

Methods and materials

Field trial sites were established in four *Actinidia chinensis* var. *deliciosa* 'Hayward' blocks and four Gold3 (*Actinidia chinensis* var. *chinensis* 'Zesy002') blocks, prior to flowering in 2017. The orchards were located in four growing regions: Gisborne, Maketu, Te Puna and Waikato. There were 16 single replicate vines labelled at each site, half were untreated controls and the other half were sprayed with Aureo Gold twice during flowering (approximately 10–30% and 80–90%), and then again at early fruit set and late fruit set.

The percentage fruit set was measured by counting the number of flower buds before flowering within marked areas of canopy and then counting the number of fruitlets 2–3 weeks post flowering. Fruit were harvested (18 fruit/vine) from two of the Gold3 orchards and two of the 'Hayward' orchards and evaluated for dry matter, °Brix, fruit weight and shape and storage firmness and incidence of rots. Fruit from one Gold3 and one 'Hayward' sites were harvested (10 fruit/vine) and evaluated for the number of seeds/fruit and fruit weight.

Key results

- There were no observations of a physical spray residue on any of the Gold3 or 'Hayward' fruit.
- The percentage fruit set in the 'Hayward' and Gold3 was 95% and 92%, respectively, and there was no evidence to suggest that spray application of Aureo Gold during the flowering and fruit set period had any effect on percentage fruit set.
- The storage trial results indicated there was also no evidence to suggest that spray application of Aureo Gold had any effect on the incidence of storage rot or fruit firmness during 16 weeks of cold storage for both Gold3 and 'Hayward' fruit.

- Each of the harvest quality parameters (dry matter, °Brix, fruit weight and shape) were shown to have not been affected by spray application of Aureo Gold during the flowering and fruit set period for both Gold3 and 'Hayward' fruit.
- The mean number of seeds/fruit was also not affected by spray application of Aureo Gold during the flowering and fruit set period for both Gold3 and 'Hayward' fruit.

Conclusions

These data indicate that there were no adverse effects arising from multiple spray applications of Aureo Gold during flowering and fruit set, in terms of percentage fruit set or fruit weight and shape, dry matter and °Brix, at harvest. The incidence of storage rot and soft fruit and number of seeds/fruit was also not affected by spraying with Aureo Gold.

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1 INTRODUCTION

The New Zealand Institute for Plant and Food Research Limited (PFR) have developed a new yeast-based biological control agent (BCA) that has activity against bacterial canker of kiwifruit, caused by *Pseudomonas syringae* pv. *actinidiae* (Psa). This BCA (coded YBCA5), is being licensed to Arysta LifeScience NZ Ltd and they have submitted a Product Registration package (trade name Aureo® Gold) to the Agricultural Compounds and Veterinary Medicines (New Zealand Food Safety Authority; New Zealand) for approval.

The objective of this project was to provide reassurance that spray application of Aureo Gold to kiwifruit during the flowering and fruit set growth period does not adversely affect fruit set, seed count, harvest indices (dry matter, °Brix, fruit weight and fruit shape) or storage quality (firmness and rots).

2 METHODS AND MATERIALS

2.1 Trial establishment

Field trial sites were established in four *Actinidia chinensis* var. *deliciosa* 'Hayward' blocks and four Gold3 (*Actinidia chinensis* var. *chinensis* 'Zesy002') blocks, prior to flowering in 2017. The orchards were located in four growing regions, Gisborne, Maketu, Te Puna and Waikato. The combination of cultivar, growing region and orchard site is shown in Table 1. Subcontractors (Lewis Wright Valuation and Consultancy Limited and Eurofins Agrosience Services Limited) were employed to carry out all spray applications and fruit set assessments at the Gisborne and Te Puna trial sites, respectively, and PFR staff carried out all spray applications and fruit set assessments at the Maketu and Waikato trial sites.

Table 1. Cultivar, growing region and orchard site for eight trial sites used to evaluate flowering and fruit set spray applications of the biological, Aureo® Gold during spring 2017.

Cultivar	Growing region	Orchard
'Hayward'	Gisborne	Site A1
Gold3	Gisborne	Site B2
'Hayward'	Maketu	Site C3
Gold3	Maketu	Site C4
'Hayward'	Te Puna	Site D5
Gold3	Te Puna	Site D6
'Hayward'	Waikato	Site E7
Gold3	Waikato	Site E8

There were 16 single vines (8 replicates per treatment) labelled at each site, half were untreated controls and the other half were sprayed with Aureo Gold (50 g/ 100 L using a water rate of 1000 L/ha) on four occasions. Aureo Gold was applied twice during flowering (approximately 10–30% and 80–90%), and then again at early fruit set and late fruit set. The spray adjuvant Bond® Xtra (60 mL/100 L) was used for all spray applications. The Aureo Gold granules used for all these trials was sourced from the commercial manufacturer and were from the pre-commercial batch #9 (V901HO) received from the supplier in early October 2017. Spray records are detailed in Appendix 1.

2.1.1 Fruit set – eight sites

Just prior to flowering, at each of the eight trial sites, bud counts were carried out in each plot by marking a fixed area of canopy using coloured tape and counting the number of flower buds present within this canopy zone. Either two or four areas of canopy were marked in each plot and a target of at least 100 buds per plot were counted. Two to three weeks after the end of flowering, the number of set fruit in these same marked canopy areas were counted so that percentage fruit set could be calculated for the treated and untreated vines.

2.1.2 Storage trials – four sites

Just prior to commercial harvest, fruit were harvested from four of the trial sites (C3, C4, E7 and E8) for placing into a storage trial to evaluate the development of any fruit rots or other symptoms. Harvest occurred on 3 and 4 April 2018 for the two Gold3 blocks (C4 and E8) and on 18 April 2018 (C3) and 18 May 2018 (E7) for the two 'Hayward' blocks. Fifty-six fruit were harvested from each vine and placed into a large paper rubbish bag (Kleensak, 890 x 395 x 125 mm). These fruit were then gently jumbled by tipping the bag end over end by hand 10 times to simulate commercial fruit handling and provide surface contact between fruit and picking wounds. Two fruit were sampled at random and put aside for determining fruit firmness. The remaining fruit were packed into commercial export trays with liners and transported to a cold store (0–1°C) at Ruakura and stacked onto a pallet.

After 8 weeks and 16 weeks all fruit were inspected for the presence of rots (including rots originating from wounds) and soft fruit. Any fruit with rot or premature softening were removed from the trays to avoid ripening the remaining fruit. At each assessment two fruit from each plot were taken for determining fruit firmness.

2.1.3 Harvest quality parameters – two sites

Just prior to commercial harvest, a random fruit sample of 18 fruit/vine was collected from the 'Hayward' and Gold3 trials located at sites C3 and C4. Fruit were sampled in a 3 x 3 grid pattern on each side of the vine, placed into commercial export trays and transported to the FASTLab fruit processing laboratory at the Te Puke Research Orchard. Fruit were assessed for fruit weight, °Brix, dry matter and any fruit shape defects using their standard protocols.

2.1.4 Seed counts and fruit weight – two sites

At the same time as sampling fruit for the FASTLab, 10 fruit/vine were also collected from each vine at sites C3 and C4 and returned to Ruakura for determining the number of seeds per fruit. These fruit were weighed individually and then allowed to ripen slowly naturally over several weeks. Fruit were then placed into a freezer for at least 2 days and then thawed at intervals for

processing. The thawed fruit were peeled to remove the skin and the remaining fruit flesh and seeds were placed in a plastic bag (300 x 450 mm), spread out and squashed so that individual seeds were separate from each other. A photo was taken (DX AF-S Nikkor, Nikon®) and the resulting image was analysed for the total number of seeds/fruit using Nikon software (NIS Elements, Br ver. 4.3).

2.2 Statistical analysis

2.2.1 Fruit set

Logistic regression was used to model the fruitlet data as numbers of “success” out of the buds as binomial totals. Where the percentage fruit set was recorded as being greater than 100%, i.e. number of fruitlets was greater than number of buds (which can occur due to counting errors), these data were labelled as invalid and were removed from the analysis (approximately 30% of the data). Hierarchical Generalised Linear Model (HGLM) was then used to analyse the fruitlet/bud ratio as a percentage with binomial distribution for the fixed and beta distribution for the random effect. There was no evidence to suggest differences among the regions ($P=0.973$). The design over the regions was severely unbalanced. We used Orchard*Cultivar*Trt as fixed and Region.PlotNum/Quadrat as random effect. The calculations were performed by GenStat 17.

2.2.2 Storage trials

For fruit firmness Linear Mixed Model (LMM) was used with Restricted Maximum Likelihood (REML) estimate for each cultivar on Firmness. The fixed effect was Site/(Treatment*Time) since the results were overly dispersed on the sites for 'Hayward' and the block effect was Site.Plot/Fruit.

For storage rot incidence the analysis was performed for the 16-week data as there was not enough variation in the 8-week data to do sensible analysis. Generalised Linear Mixed Model (GLMM) was used with REML estimate and binomial distribution. The fixed effect was Site/Treatment and the block effect was Site.Plot. The analysis was at logit scale for binomial distribution and the mean and confidence limits were then back transformed. The incidences of fruit with rot and fruit with rots associated with wounds were combined and analysed alongside the incidence of fruit that were soft, with number of fruits as the binomial total.

2.2.3 Harvest quality parameters

Linear Mixed Model (LMM) was used with REML estimate for both cultivars on fruit weight. The fixed effect was Treatment and the block effect was PlotName (the vines).

2.2.4 Seed counts and fruit weight

Generalised Linear Mixed Model (GLMM) was used with REML estimate and Poisson distribution. The fixed effect was Cultivar/Treatment and the block effect was Cultivar.VineNo. The analysis was performed on individual fruits rather than the averages per vine to take within-vine variation into account. The analysis was at log scale for Poisson distribution. The mean and confidence limits were then back transformed.

3 RESULTS

3.1.1 Fruit set

Percentage fruit set was significantly higher ($P=0.003$) in 'Hayward' compared with Gold3 and there was also evidence to suggest a significant difference in the percentage fruit set between the orchards ($P<0.001$). However, there was no evidence to suggest a difference in the percentage fruit set between the untreated Nil controls and the Aureo Gold treated vines ($P=0.59$), nor was there a cultivar by treatment interaction ($P=0.80$; Table2).

Table 2. Mean percentage fruit set on *Actinidia chinensis* var. *deliciosa* 'Hayward' and Gold3 (*Actinidia chinensis* var. *chinensis* 'Zesy002') vines (from four orchards per cultivar) that were untreated or sprayed four times with Aureo® Gold) during flowering and fruit set at the start of the 2017 season.

Cultivar	Treatment	% Fruit set	95% Confidence intervals
Gold3	Nil control	92.2	(89.5–94.2)
Gold3	Aureo Gold	91.5	(88.4–93.8)
'Hayward'	Nil control	95.4	(93.4–96.8)
'Hayward'	Aureo Gold	94.9	(92.9–96.3)

3.1.2 Storage trials

There was no fruit rot in the 'Hayward' fruit after 8 and 16 weeks' cold storage. There was however, some development of soft fruit, with 1–2% incidence from site E7 and 5–6% from site C3 although no treatment effect ($P=0.77$) resulting from spraying with Aureo Gold.

The fruit firmness in the 'Hayward' fruit at harvest was 13.0–13.3 kg at site E7 and unfortunately these data were not collected from site C3. After 8 weeks fruit firmness was similar in the fruit from site E7 and C3, 6.8–7.4 and 7.4–7.8 kg, respectively. After 16 weeks fruit had softened further and ranged from 3.2–4 kg across both sites. There was no significant treatment effect on 'Hayward' fruit firmness ($P=0.07$) resulting from spraying with Aureo Gold.

For the Gold3 fruit there was a low level of incidence of fruit rot and fruit with rots from apparent wounds (site E7 = 0.8–1.4% and site C3 = 1.3–1.5%) and no treatment effect ($P=0.70$) resulting from spraying with Aureo Gold. The incidence of soft Gold3 fruit was 0 at site E7 and 1–3% at site C3 and again for both sites there was no treatment effect ($P=0.15$) resulting from spraying with Aureo Gold.

The Gold3 fruit were significantly ($P<0.001$) softer, ranging from 5.8–6.9 kg across both sites at harvest, compared with the 'Hayward' fruit. Unfortunately the 8 week assessments for fruit firmness were compromised due to an instrumental error relating to default settings not being appropriately set. After 16 weeks fruit firmness for Gold3 ranged from 3.3–4.6 kg across both sites. For both sites there was no treatment effect on fruit firmness ($P=0.52$) resulting from spraying with Aureo Gold.

3.1.3 Harvest quality parameters

The 18 fruit/vine sample that was processed by the FASTLab at Te Puke Research Centre indicated that neither fruit weight, nor dry matter nor °Brix were significantly affected as a result of spraying with Aureo Gold (Table 3).

The other fruit quality parameters assessed by the FASTLab included, flats and fans (misshapen), “Hayward-mark” (a deformed line down the side of the fruit with a protuberance), “drop shoulder” (a sloping (>15° angle) across the stalk-end of the fruit, resulting from uneven pollination) and physical blemishes. For the Gold3 fruit there were 0–5 fruit (<2%) in each of these categories and there was no effect as a result of spraying with Aureo Gold. For the ‘Hayward’ fruit there was a higher incidence of flats and fans (7.6–9.3%) and a similar low incidence of drop shoulder (<2%), and again there was no effect as a result of spraying with Aureo Gold.

Table 3. Mean fruit weight, dry matter and °Brix for kiwifruit treated with four spray applications of Aureo® Gold over flowering and fruit set, compared with unsprayed fruit from sites C3 and C4.

Cultivar	Treatment	Fruit weight	Dry matter	°Brix
Gold3	Nil control	130.8	17.3	7.0
Gold3	Aureo Gold	130.5	17.5	7.0
	SEM ¹	3.3	0.21	0.15
	<i>P</i> -value	0.95 (NS) ²	0.43 (NS)	0.96 (NS)
‘Hayward’	Nil control	136.5	17.8	5.9
‘Hayward’	Aureo Gold	129.7	17.6	5.9
	SEM	2.4	0.15	0.07
	<i>P</i> -value	0.07 (NS)	0.26 (NS)	0.47 (NS)

¹ SEM = standard error of the mean

² NS = No significant difference between the nil and Aureo gold treatments (>0.05).

3.1.4 Seed counts and fruit weight

The mean number of seeds/fruit was ranged from 402–405 for Gold3 and 1271–1273 for 'Hayward', indicating no difference ($P=0.87$) between untreated fruit and fruit sprayed with Aureo Gold over flowering and fruit set (Table 4).

The mean fruit weight from this fruit sample was 120–127 g for Gold3 and 105–106 g for 'Hayward', again indicating no difference ($P=0.26$) between untreated fruit and fruit sprayed with Aureo Gold over flowering and fruit set.

Table 4. Mean number of seeds/fruit from fruit treated with four spray applications of Aureo® Gold over flowering and fruit set, compared with unsprayed fruit from site C3.

Cultivar	Treatment	Seeds/fruit	95% Confidence intervals
Gold3	Nil control	405	(384–428)
Gold3	Aureo Gold	402	(380–424)
'Hayward'	Nil control	1273	(1229–1319)
'Hayward'	Aureo Gold	1271	(1227–1317)

4 CONCLUSIONS

These results indicate that there were no adverse effects on fruit set or the fruit quality parameters evaluated in this study arising from multiple spray applications of Aureo Gold during flowering and fruit set.

5 ACKNOWLEDGEMENTS

We would like to thank Trevor Lupton (Lewis Wright Valuation and Consultancy Ltd) and Tim Ranchodbhai (Eurofins Agrosience Services Limited) for competently carrying out the spraying and fruit set assessments at the Gisborne and Te Puna trial sites. Many thanks to Mike Spiers for editorial assistance and for helping with fruit sampling. Thanks also to Jennifer Parry for assisting with fruit set assessments in the Waikato orchard.

APPENDIX 1 – SPRAY RECORDS

Application details for Site A1 – Gisborne *Actinidia chinensis* var. *deliciosa* 'Hayward'.

Application timing	10% flowering	100% flowering	Mid fruit set	Late fruit set
Date	9 Nov. 2017	16 Nov. 2017	24 Nov. 2017	3 Dec. 2017
Start time	15:50	17:30	16:00	13:30
Water / plot (L)	1.2	1.2	1.2	1.2
Water / Ha (L)	1000	970	950	960
Spray pressure	600 kpa	600 kpa	600 kpa	600 kpa
Weather description	Fine/cloudy	Cloudy	Fine	Fine/cloudy
Wind speed (km/h)	2.5	1.5	2.5	0
Wind direction	NE	NE	SE	-
Temperature (°C)	19°C	21°C	22°C	30°C
Relative humidity (%)	60%	50%	55%	55%
Cloud cover (%)	40%	80%	5%	20%
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Echo® SHR150si Motorised Knapsack with twin nozzle (TXVK 10)

Application details for Site B2 – Gisborne Gold3 (*Actinidia chinensis* var. *chinensis* 'Zesy002').

Application timing	5-30% flowering	50-90% flowering	Early fruit set	Late fruit set
Date	22 Oct. 2017	30 Oct. 2017	6 Nov. 2017	16 Nov. 2017
Start time	17:30	16:55	16:40	18:00
Water / plot (L)	1.5	1.7	1.6	1.6
Water / Ha (L)	909	1030	947	950
Spray pressure	600 kpa	600 kpa	600 kpa	600 kpa
Weather description	Overcast	Fine	Fine/cloudy	Overcast
Wind speed (km/h)	3.0	3.0	2.5	1.5
Wind direction	NW	NE	NE	SW
Temperature (°C)	20°C	21.5°C	22°C	16°C
Relative humidity (%)	65%	60%	45%	80%
Cloud cover (%)	100%	0%	80%	100%
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	Light rain 2 h after	0

Sprayer used = Echo® SHR150si Motorised Knapsack with twin nozzle (TXVK 10)

Application details for Site C3 – Maketu 'Hayward'.

Application timing	60-70% flowering	90% flowering	Early fruit set	Late fruit set
Date	16 Nov. 2017	17 Nov. 2017	27 Nov. 2017	5 Dec. 2017
Start time	18:00	18:30	11:00	11:30
Water / plot (L)	3.5	2.6	2.0	3.0
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	150 psi	150 psi	150 psi	150 psi
Weather description	Calm	Slight breeze	Slight breeze	Calm
Wind speed (km/h)	0–2	2–4	2–4	0
Wind direction	-	W	NW	-
Temperature (°C)	21°C	20°C	21°C	24°C
Relative humidity (%)	-	-	-	-
Cloud cover (%)	-	-	-	-
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Hand gun and pressurised sprayer.

Application details for Site C4 – Maketu Gold3.

Application timing	5% flowering	90% flowering	Early fruit set	Late fruit set
Date	26 Oct. 2017	1 Nov. 2017	7 Nov. 2017	16 Nov. 2017
Start time	18:30	18:00	11:30	11:00
Water / plot (L)	2.4	2.9	2.6	2.7
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	150 psi	150 psi	150 psi	150 psi
Weather description	Fine	Fine	Fine	Overcast
Wind speed (km/h)	1–6	0–1	1–3	3
Wind direction	NW	-	NW	W
Temperature (°C)	18°C	19°C	18°C	23°C
Relative humidity (%)	-	-	-	-
Cloud cover (%)	-	-	-	-
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Hand gun and pressurised sprayer.

Application details for Site D5 – Te Puna 'Hayward'.

Application timing	5-10% flowering	80-90% flowering	Mid fruit set	Late fruit set
Date	14 Nov. 2017	20 Nov. 2017	27 Nov. 2017	5 Dec. 2017
Start time	11:30	13:00	10:00	9:30
Water / plot (L)	-	-	-	-
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	400 kpa	400 kpa	400 kpa	400 kpa
Weather description	Sunny/overcast	Fine	Overcast	Fine
Wind speed (km/h)	0–5	0–5	0–5	0–5
Wind direction	NE	S	SW	SE
Temperature (°C)	20°C	24°C	17°C	22°C
Relative humidity (%)	70%	55%	55%	65%
Cloud cover (%)	80–90%	80%	80–90%	10–20%
Foliage wetness	Moist	Dry	Moist	Dry
Rainfall				
Day of application	Rain early morning	0	Rain early morning	0

Sprayer used = Solo motorised knapsack with twin nozzle (TXVK 18)

Application details for Site D6 – Te Puna Gold3.

Application timing	5-10% flowering	80-90% flowering	Early fruit set	Late fruit set
Date	1 Nov. 2017	6 Nov. 2017	13 Nov. 2017	20 Nov. 2017
Start time	11:30	9:30	14:00	12:00
Water / plot (L)	-	-	-	-
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	400 kpa	400 kpa	400 kpa	400 kpa
Weather description	Overcast/Gusty	Gusty	Fine	Fine
Wind speed (km/h)	0–8	5–10	0–5	0–5
Wind direction	NW	NW	NE	S
Temperature (°C)	20°C	17°C	18°C	25°C
Relative humidity (%)	67%	58%	60%	50%
Cloud cover (%)	80–90%	20–30%	30%	60–70%
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Solo motorised knapsack with twin nozzle (TXVK 18)

Application details for Site E7 – Waikato 'Hayward'.

Proposed application timing	40% flowering	100% flowering	Early fruit set	Late fruit set
Date	22 Nov. 2017	28 Nov. 2017	4 Dec. 2017	11 Dec. 2017
Start time	19:50	18:50		
Water / plot (L)	2.4	2.7	2.7	2.7
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	150 psi	150 psi	150 psi	150 psi
Weather description	Clear light breeze	Cloudy, calm	Fine	Fine, calm
Wind speed (km/h)	0–2	0	0	0
Wind direction	-	-	-	-
Temperature (°C)	22°C	22°C	27°C	24°C
Relative humidity (%)	-	-	-	-
Cloud cover (%)	0	50–80%	0	0
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Hand gun and pressurised sprayer.

Application details for Site E8 – Waikato Gold3.

Proposed application timing	30% flowering	90% flowering	Early fruit set	Late fruit set
Date	2 Nov. 2017	7 Nov. 2017	18 Nov. 2017	22 Nov. 2017
Start time	18:15	18:30	18:30	18:45
Water / plot (L)	2.5	2.5	2.5	2.5
Water / Ha (L)	1000	1000	1000	1000
Spray pressure	150 psi	150 psi	150 psi	150 psi
Weather description	Cloudy	Sunny	Cloudy	Sunny
Wind speed (km/h)	2–5	1–5	3–6	2–4
Wind direction	W	W	SE	W
Temperature (°C)	19°C	18°C	16°C	24°C
Relative humidity (%)	-	-	-	-
Cloud cover (%)	60%	0%	40–60%	0%
Foliage wetness	Dry	Dry	Dry	Dry
Rainfall				
Day of application	0	0	0	0

Sprayer used = Hand gun and pressurised sprayer.



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