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Report to Zespri Group Ltd

Aerial spray deposit studies on kiwifruit

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EXECUTIVE SUMMARY

This study was undertaken to provide prescriptions for the aerial application of protectant sprays to kiwifruit. In particular, to determine guidelines for low volume aerial spray applications, using organosilicone superspreader adjuvants.

The studies were undertaken pre-harvest in March/April 2011 on three Paengaroa orchards, on pergola canopies comprising (1) dense Hort 16A, (2) Hort 16A with strings, and (3) typical Hayward. Deposits from a 600 L/ha dilute spray application were compared with two- and three-times concentrate sprays (300 L/ha and 200 L/ha, respectively) with the addition of either Du-Wett Rainmaster or Du-Wett adjuvant at varying rates. Deposits on foliage (upper, mid, lower and string canopy zones) and fruit were quantified.

In summary:

- Aerial sprays do not penetrate well into any pergola canopies and will only target leaves on the top of the canopy; these intercept ca 70% of an aerial spray.
- The undersides of leaves are poorly targeted by aerial sprays.
- No aerial sprays were deposited on fruit, thus such operations on dense, pre-harvest canopies are unlikely to contribute to chemical residues.
- Generally, low volume (200 L/ha) sprays performed similarly to higher volume (600 L/ha) sprays and are justified on the basis of cost.
- There was some evidence that aerial spray deposits on pergola canopies can be increased by reducing the flight height and presumably, also reducing off-target drift. This requires confirmation.
- Du-Wett Rainmaster adjuvant can be used to rainfasten sprays on upper surfaces of leaves; it should be added to aerial sprays at 700 ml/ha to ensure good coverage of leaf surfaces.
- Du-Wett adjuvant should be used preferentially (350 ml/ha), to minimise costs, when rainfastening of sprays is not required.
- Limited comparisons with deposits from airblast sprays suggest aerial sprays will provide better protection to foliage, primarily the topside of leaves, on the top of pergola canopies.

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Aerial spray deposit studies on kiwifruit

Introduction

The infection of kiwifruit by *Pseudomonas syringae pv Actinidiae* (Psa) occurs via airborne bacterium, meaning it is easily spread by rain and wind. It is probable that the bacterium infects new orchards primarily by airborne transmissions settling on exposed foliage on the tops of vine canopies. Protecting these potential sites of infection is not readily achieved with conventional ground-based, airblast spray applications. Aerial spray application is not commonly undertaken on kiwifruit, but offers the potential to apply protectant sprays rapidly and effectively to dense pergola canopies. The cost of aerial spray applications depends directly on the spray carrier volumes applied per hectare; minimising volume reduces cost for growers. This study aimed to determine how well aerial sprays could cover/penetrate vine canopies, if low volume sprays could perform similarly to higher volumes, and to provide guidelines and superspreader adjuvant prescriptions for the aerial application of protectant sprays to kiwifruit.

Field trials were undertaken pre-harvest in late March/April 2011 on three Paengaroa orchards, on (1) a dense Hort 16A, (2) a Hort 16A with strings, and (3) a typical Hayward canopy. Spray deposits were monitored to determine how effective the aerial sprays were in covering and penetrating the different kiwifruit canopies.

STUDY 1: AERIAL SPRAY DEPOSITS ON A DENSE HORT 16A CANOPY

This study investigated the effect of three different aerial spray volumes on spray distribution and deposition on foliage and fruit in a dense Hort 16A pergola canopy. The effect of varying rates of a rainfastening, superspreader sticker adjuvant, Du-Wett Rainmaster, on spray deposits was also determined.

Methods and Materials

The trial was undertaken on 29 March 2011, on PE Christiansen's orchard, 443 SH 33, near Paengaroa (Appendix 1). Sprays were applied to the Aspen Block, 4.38 ha in size, divided into similar sized blocks with approx. 5 m tall shade cloth. The Hort 16A pergola canopy was very dense, unstrung and carrying a heavy crop of fruit ready for harvest. Each treatment was applied to one large plot (ca 0.2 ha), running NW-SE (Appendix 1). Plots were separated by the 5 m tall shade cloth on their NE boundaries. All sprays were applied between 12.20-4.20 pm in warm, still conditions. Meteorological data was recorded for each treatment (Appendix 2). Treatments were applied with a Squirrel AS350 BA helicopter (Oceania Helicopters Tauranga Ltd) piloted by Glenn Olliff, through 40 TeeJet XR8010SS nozzles (nominal 540 µm VMD) mounted on an 8 m boom (Photo Plate 1). The helicopter flew three swaths (NW-SE) per block for each treatment at a mean height of 26 m above ground level. GPS flight lines and standard flight details were recorded for each treatment.

Photo Plate 1: Squirrel Helicopter and nozzle setup on boom

Application parameters for each treatment are recorded in Table 1. Dilute spray application rate was 600 litres/ha, 2x concentrate was 300 L/ha and 3x concentrate was 200 L/ha (Table 1). The 2x concentrate volume was achieved by blocking off alternate nozzles on the boom; the 3x concentrate volume was achieved by increasing the flying speed with 2x concentrate nozzling (Table 1).

Table 1: Treatment log (all sprays contained Du-Wett Rainmaster adjuvant[1])

Tmt #	Spray volume (L/ha)	Spray concentratn factor	Adjuvant[1] rate		Time sprayed	Flying speed	Pressure	Flow rate
			ml/ha	%		knots	Bar	L/sec
1	600	dilute	700	0.12	1222	14	4.0	3.33
2	300	2x	500	0.17	1258	14	4.0	1.66
3	300	2x	700	0.23	1327	14	4.0	1.66
4	200	3x	500	0.25	1357	20	4.0	1.66
5	200	3x	700	0.35	1424	20	4.0	1.66

All treatments (Table 1) contained varying rates of a superspreader-sticker adjuvant, Du-Wett® Rainmaster™ (DW-RM; Etec Crop Solutions). This was included as the most likely adjuvant to provide good rainfastening of protectant sprays (Gaskin 2011, Gaskin & Steele 2009). Also included in all sprays was Calcium 175 (175 g/L elemental calcium, Gro-Chem; approx. 10 L/ha) as a tracer. (Note that Du-Wett Rainmaster is prescribed at 2x the normal Du-Wett use rate. Also it was unnecessary to include Kocide Opti or Serenade in sprays as laboratory tests confirmed they had no physical effect, at recommended use rates, on the properties of the sprays containing the adjuvant.) Water sensitive papers were stapled to the abaxial (underside) of four random leaves in the top canopy zone in each treatment.

Each treatment was sampled before the next one was sprayed. Samples of foliage were taken from three canopy zones in each treatment. The sample zones were the top (directly exposed to the spray), mid and lower canopy. At harvest, after spray had dried, foliage (5 leaves per replicate) and fruit (4 fruit per replicate) samples were collected into re-sealable ziplock plastic bags. Ten replicates of leaves in each canopy zone and ten replicates of fruit were randomly sampled from each treatment plot and from an unsprayed control plot. Fruit samples were weighed prior to washing. Leaf and fruit samples were washed within 15 mins of harvest in 200 ml distilled water containing 0.05% Du-Wett surfactant. Ca ion levels in all wash solutions were quantified using a portable ion conductivity meter (Russell RL060C). Leaf areas were subsequently measured using a Leaf Area Meter (Li-Cor 3100).

Fruit and leaf deposits were calculated as dose applied (μg/g and μg/cm^2, respectively). Note that fruit and leaf deposits cannot be compared directly because fruit deposits are calculated on a weight basis and leaf deposits on an area basis. All treatments contained calcium at identical rates per ha. However, residual water volumes in the spray tank vary slightly and affect the applied tracer concentrations. To correct for this, calcium ion concentrations in each treatment were normalised to an equivalent of 1 kg/ha, based on spray sampled from the helicopter tank immediately pre-and post-application. Deposit data were transformed where necessary and compared using analysis of variance to determine the significance of canopy zone on spray deposits retained on fruit and foliage.

RESULTS

There were generally no significant differences in the spray deposited by different treatments on each canopy zone (Table 2). More than 60% of retained spray deposits landed on the top leaves exposed to the aerial spray, and <10% of deposits were intercepted by the sheltered foliage closest to the ground. On this very heavy gold canopy, fruit intercepted no spray deposits at all. The top leaves of the pergola canopy appeared to tile in the downwash from the helicopter and create a solid barrier to intercept spray deposits and prevent any penetration of spray deeper into the canopy.

Table 2: Aerial spray deposits on Hort 16A foliage and fruit

Tmt #	Spray volume (L/ha)	DW-RM adjuvant rate ml/ha	Canopy zone leaf deposits ($\mu g/cm^2$)				Fruit deposits ($\mu g/g$)
			top	mid	lower	**Tmt Mean**	
1	600	700	1.22 a	0.58 bc	0.13 e	**0.64 A**	0
2	300	500	0.77 b	0.53 bcd	0.13 e	**0.48 B**	0
3	300	700	1.16 a	0.47 cd	0.15 e	**0.59 AB**	0
4	200	500	1.39 a	0.65 bc	0.15 e	**0.73 A**	0
5	200	700	1.35 a	0.48 cd	0.26 de	**0.70 A**	0
Canopy zone Mean			*1.18 A*	*0.54 B*	*0.16 C*		0

Means sharing common postscripts are not significantly different (LSD test, P<0.05)

The trend was for the lowest volume treatments (200 L/ha) to receive highest deposits (Table 2 & Fig. 1). There was no clear effect of adjuvant rate at these aerial application volumes except that coverage of the adaxial (upper) leaf surface was always visibly greater with the higher DW-RM rate of 700 ml/ha than with 500 ml/ha. The abaxial (underside) leaf surface of leaves in the top canopy zone received minimal spray deposits (Fig. 2), consistent with the 'tiling' effect of the helicopter downwash.

Wind was consistently light throughout this study and there was little variation in air temperature or humidity (Appendix 2). The release height of sprays varied by only 3 m (Appendix 2) but the lowest spray height corresponded to the highest spray deposits and vice-versa. It is likely that releasing spray from a greater height above the canopy results in more off-target drift, i.e. lower deposits on target.

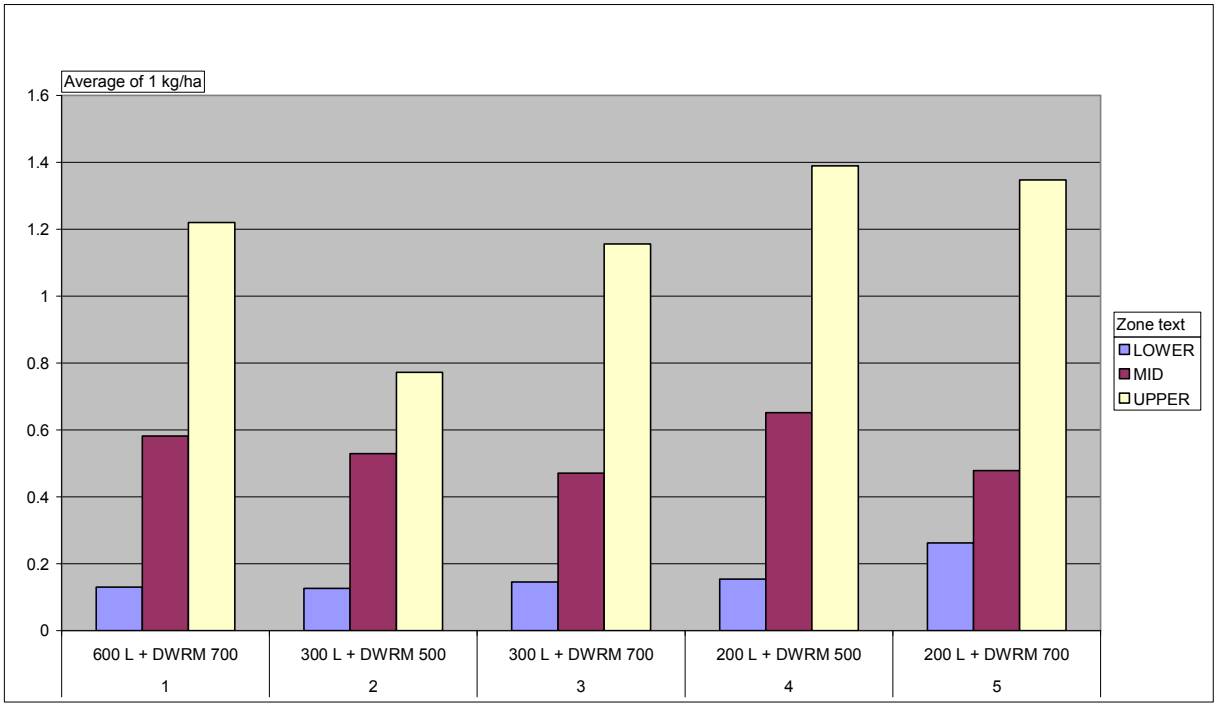

Fig. 1: Aerial spray deposits on foliage in the lower, mid and upper canopy zones on a Hort 16A pergola.

Tmt #1

Tmt #3

Tmt #5

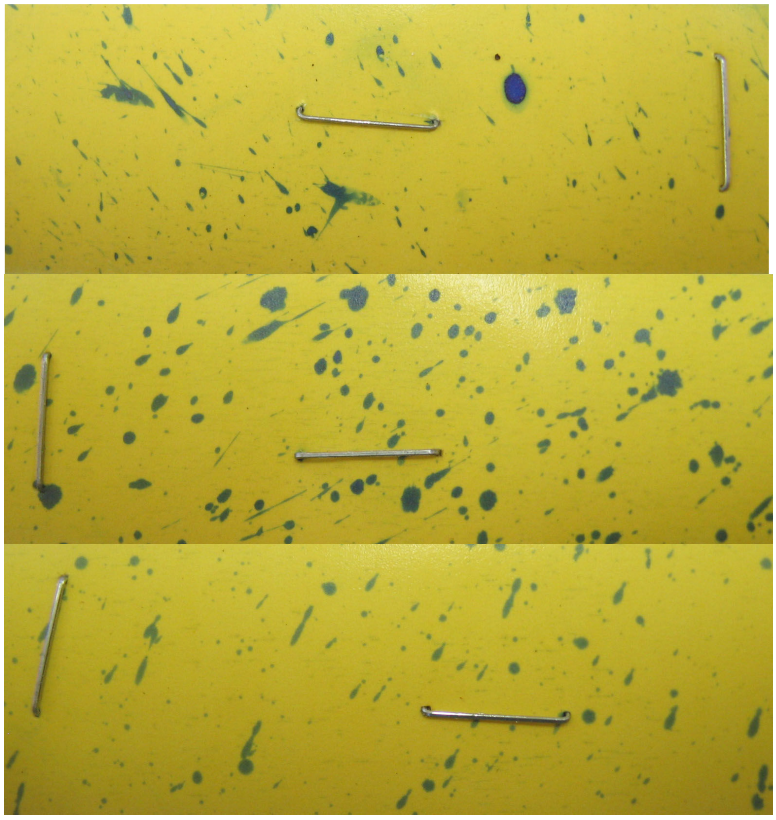

Fig. 2: Water sensitive papers showing typical highest spray deposits intercepted on the underside of leaves in the top canopy zone for three treatments.

CONCLUSIONS

- Leaves in the top canopy zone of a dense Hort 16A pergola, directly exposed to aerial sprays, received >60% of spray deposits.

- Leaves in the sheltered mid and lower canopy zones received much lower deposits, of <30% and <10% of total, respectively. No spray was deposited on fruit.

- Use of a higher rate of DW-RM adjuvant improved spray coverage of leaf surfaces.

- The underside of leaves, even of those top leaves directly exposed to aerial sprays, received minimal spray deposits.

- Higher release heights of sprays may reduce on-target deposits.

STUDY 2: AERIAL SPRAY DEPOSITS ON A STRUNG HORT 16A CANOPY

This study investigated the effect of three different aerial spray volumes on spray distribution and deposition on foliage and fruit in a strung Hort 16A pergola canopy. The effect of varying rates of a rainfastening superspreader sticker adjuvant, Du-Wett Rainmaster, on spray deposits was also determined.

Methods and Materials

The trial was undertaken on 30 March 2011, on the Longview Trust Orchard (owner M McBride; orchard manager Leighton Oates), 443 SH 33, near Paengaroa (Appendix 1). Sprays were applied to the Georgia Block, which is 5.12 ha in size and divided into two large blocks (one covered with shade cloth) and two similar sized smaller blocks. The Hort 16A pergola canopy was dense, strung to about 5 m high and carrying a heavy crop of fruit (Photo Plate 2). Each treatment was applied to one large plot (ca 0.30 ha), running NE-SW (Appendix 1). Blocks were separated by 5 m tall shade cloth on their SE boundaries. All sprays were applied between 11.10 am-2.05 pm in warm, often blustery (12-18 km/h) wind conditions. Meteorological data was recorded for each treatment (Appendix 2). Treatments (Table 3) were applied with the same helicopter and configuration as in Study 1. The helicopter flew three swaths (NE-SW) for each treatment at a mean height of 18 m above ground. GPS flight lines and standard flight details were recorded for each treatment.

Photo Plate 2: Strung Hort 16 A pergola canopy

Application parameters for each treatment are recorded in Table 3. Spray application rate was adjusted as described in Study 1. Foliage was sampled, treated and processed as described in Study 1 with the addition of leaves sampled from the above-canopy strings. Leaves were picked equally from both upper (exposed) and lower (shaded)

canopy surfaces on vertical strings, at 3.5-4 m above the ground. Fruit was not sampled in this study, based on the results in Study 1 and the assumption that no spray would reach fruit through the relatively heavy canopy. Deposits were calculated as described in Study 1. Water sensitive papers were stapled to the upper sides of four random leaves in both the top and lower canopy zone in each treatment.

Table 3: Treatment log (all sprays contained Du-Wett Rainmaster adjuvant[1])

Tmt #	Spray volume (L/ha)	Spray concentration factor	Adjuvant[1] rate		Time sprayed	Flying speed	Pressure	Flow rate
			ml/ha	%		knots	Bar	L/sec
1	600	dilute	700	0.12	1112	14	4.0	3.33
2	300	2x	500	0.17	1155	14	4.0	1.66
3	300	2x	700	0.23	1240	14	4.0	1.66
4	200	3x	500	0.25	1329	20	4.0	1.66
5	200	3x	700	0.35	1405	20	4.0	1.66

Results

The results of Treatment 4 are not available. This treatment was compromised by high winds at the time of application and as a consequence was not sampled. All low volume treatments were deposited in all canopy zones similarly to the high volume 600 L/ha treatment (Table 4). The highest mean deposit was recorded for the lowest volume spray at 200 L/ha (#5), primarily due to its high deposition on strings. As on the unstrung Hort 16A canopy (Study 1), spray retained on the top leaves was much greater (72%) than on the sheltered mid (24%) and lower (4%) canopy zones. The aerial sprays did not penetrate well into the pergola canopy (Fig. 3).

Deposits recorded on vertical strings were significantly lower than on the top horizontal leaf zone in all treatments (Table 4). The strung foliage was sampled up to 2 m above the top canopy, but equally from both the exposed outer face and the sheltered underside of the strings. Thus, the string deposits are the mean of those received by exposed and sheltered leaves and were only 56% of the mean deposits measured on exposed top leaves.

Table 4: Aerial spray deposits on Strung Hort 16A foliage

Tmt #	Spray volume (L/ha)	DW-RM adjuvant rate ml/ha	Canopy zone leaf deposits (µg/cm^2)				
			strings	top	mid	lower	**Tmt Mean**
1	600	700	0.91 def	1.87 ab	0.59 fg	0.09 h	**0.87 AB**
2	300	500	1.07 de	2.09 a	0.62 fg	0.15 h	**0.98 AB**
3	300	700	1.01 de	1.66 bc	0.44 gh	0.11 h	**0.81 B**
5	200	700	1.29 cd	1.98 ab	0.83 ef	0.09 h	**1.05 A**
Canopy zone Mean			*1.07 B*	*1.90 A*	*0.62 C*	*0.11 D*	

Means sharing common postscripts are not significantly different (LSD test, P<0.05)

Wind conditions were blustery and much higher in this study than in Study 1 (Appendix 2), but deposits were still markedly higher in Study 2, except on the lower zone. The strung canopy was less dense than the unstrung canopy in Study 1, but the factor which may have contributed most to increased deposits was the lower release height of sprays. The release height was 24-27 m above ground in Study 1 compared to 14-21 m in Study 2 (Appendix 2). There was no obvious relationship between deposits and either wind speed or release height in this study, but it was encouraging that the low volume 200 L/ha spray deposits were generally higher than the 600 L/ha spray deposits, applied at a similar release height (ca 20 m) and in much stronger winds (18 km/h vs 12 km/h). This indicates some robustness of the low volume application under marginal wind conditions.

There was no clear effect of adjuvant rate in the limited data set, but the highest concentration of DW-RM (0.35% in Treatment 5) provided best coverage visibly on leaves and on water sensitive papers (Fig. 4).

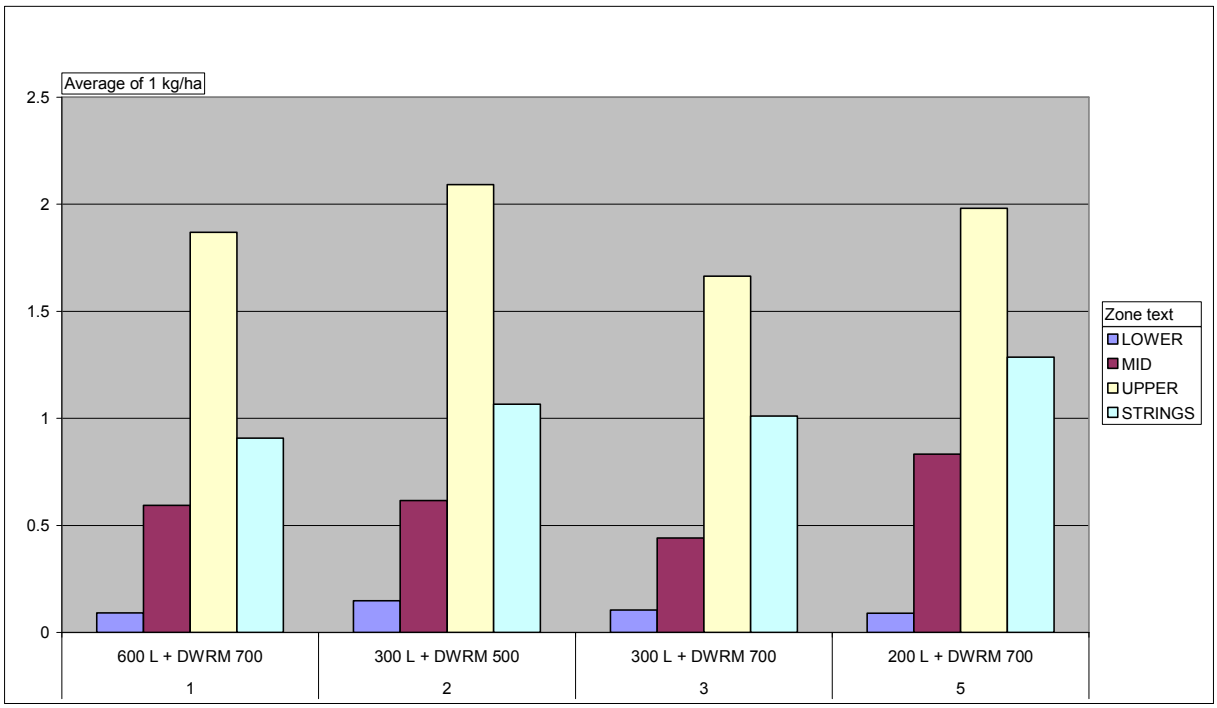

Fig. 3: Aerial spray deposits on foliage in the lower, mid, upper canopy zones and strings on a strung Hort 16A pergola.

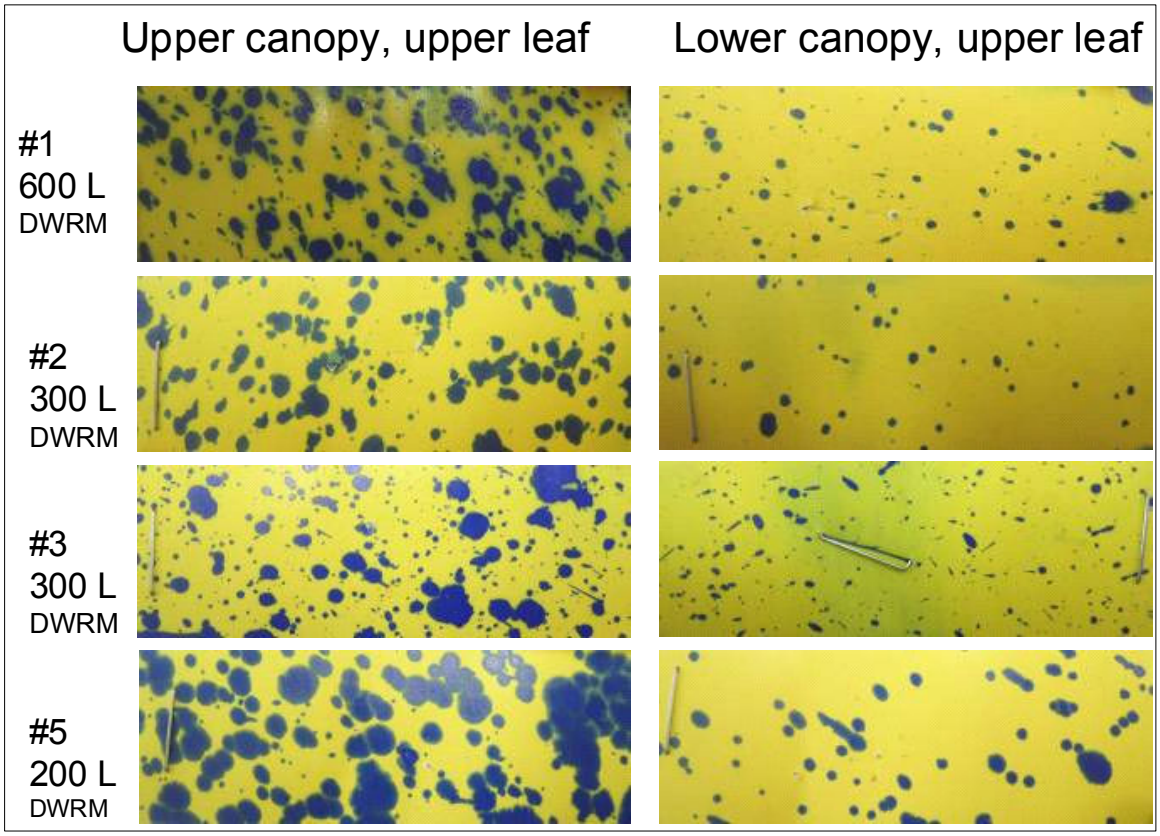

Fig. 4: Water sensitive papers showing typical highest spray deposits intercepted on the upper exposed side of leaves in the top and lower canopy zones.

CONCLUSIONS

- Leaves in the top canopy zone of a strung Hort 16A pergola, directly exposed to aerial sprays, received >70% of spray deposited on the horizontal canopy.
- Leaves in the sheltered mid and lower canopy zones received much lower deposits, of 24% and 4% of total horizontal canopy deposits, respectively.
- A low volume 200 L/ha spray provided similar deposits to 600 L/ha, even under adverse wind conditions.
- A high use rate of DW-RM adjuvant resulted in better spray coverage of leaf surfaces.
- Lower release heights of sprays in this study may have been responsible for higher on-target deposits than in Study 1.

STUDY 3: AERIAL SPRAY DEPOSITS ON A HAYWARD CANOPY

This study investigated the effect of three different aerial spray volumes on spray distribution and deposition on foliage and fruit in a Hayward pergola canopy. The effect of varying rates of a superspreader sticker adjuvant, Du-Wett Rainmaster, on spray deposits was compared to the non-rainfastening superspreader, Du-Wett.

Methods and Materials

The trial was undertaken on 11th April 2011, on Phil Leppard's orchard, 499 SH 33, near Paengaroa (Appendix 1). Sprays were applied to Blocks D, E, and F adjacent to the Stables block, all separated by 8.2 m high shelter belts. The Hayward pergola canopy (Photo Plate 3) was moderately dense and carrying a heavy crop of fruit. Each treatment was applied to one large plot (ca 0.25 ha), running NW-SE (Appendix 1). All sprays were applied between 2.35-4.37 pm in warm, relatively still conditions. Meteorological data was recorded for each treatment (Appendix 2). Treatments (Table 5) were applied with the same helicopter and configuration as in Study 1. The helicopter flew three swaths (NNW-SSE) per block for each treatment at a mean height of 12 m above ground level. GPS flight lines and standard flight details were recorded for each treatment.

Photo Plate 3: Hayward pergola canopy

Application parameters for each treatment are recorded in Table 5. Spray application rates were adjusted as described in Study 1. Treatments (Table 5) contained varying rates of either a superspreader-sticker adjuvant, Du-Wett Rainmaster or the superspreader adjuvant, Du-Wett® (Etec Crop Solutions). Du-Wett has no rainfastening activity but recent studies have shown it to have no (negative) effect on the longevity of commercial copper sprays on kiwifruit foliage (Gaskin *et al* 2011a). As such, it will be

more cost-effective to use Du-Wett (at half the rate) than Du-Wett Rainmaster with aerial copper sprays and thus, its effects on spray deposits were quantified in this study. Foliage and fruit was sampled, treated and processed as described in Study 1. Deposits were calculated as described in Study 1. Water sensitive papers were stapled to the upper sides of four random leaves in both the top and lower canopy zone in each treatment.

Table 5: Treatment log (all sprays contained either Du-Wett Rainmaster[1] or Du-Wett[2] adjuvant)

Tmt #	Spray volume (L/ha)	Spray concentratn factor	Adjuvant rate		Time sprayed	Flying speed	Pressure	Flow rate
			ml/ha	%		knots	Bar	L/sec
1	600	dilute	700[1]	0.12	1435	14	4.00	3.33
2	300	2x	700[1]	0.23	1506	14	4.00	1.66
3	300	2x	350[2]	0.12	1610	14	4.00	1.66
4	200	3x	700[1]	0.35	1538	20	4.00	1.66
5	200	3x	350[2]	0.17	1637	20	4.00	1.66

Results

In contrast to the previous studies, the high volume (600 L/ha) spray deposits were significantly higher than low volume deposits on Hayward leaves in the top canopy zone (Table 6). As in the other studies, there was very poor penetration of all sprays into the canopy and there were no differences between treatments in this respect. 75% of mean deposits were on the top canopy, 18% on the mid canopy and 6% on the lower canopy leaves. There were no deposits recovered from fruit.

Table 6: Aerial spray deposits on Hayward foliage and fruit

Tmt #	Spray volume (L/ha)	Adjuvant/ rate (ml/ha)	Canopy zone leaf deposits ($\mu g/cm^2$)				Fruit deposit ($\mu g/g$)
			top	mid	lower	**Tmt Mean**	
1	600	DWRM 700	2.49 a	0.62 d	0.26 defg	**1.12 A**	0
2	300	DWRM 700	2.01 b	0.45 def	0.27 defg	**0.91 AB**	0
3	300	DW 350	1.56 c	0.45 def	0.13 efg	**0.71 B**	0
4	200	DWRM 700	1.79 bc	0.47 de	0.04 g	**0.77 B**	0
5	200	DW 350	1.97 b	0.43 def	0.08 fg	**0.83 B**	0
Canopy zone Mean			*1.96 A*	*0.48 B*	*0.16 C*		0

Means sharing common postscripts are not significantly different (LSD test, $P<0.05$)

There was no consistent effect of adjuvant addition; Du-Wett performance was similar to DW-RM, particularly at the lowest 200 L/ha volume (Table 6 and Fig. 5). Spray coverage of leaves and of water sensitive papers (Fig. 6) was better with Du-Wett than

with 2x the rate of DW-RM, confirming the better superspreading properties of the former. It will be advantageous to use Du-Wett rather than DW-RM whenever possible to save costs. Copper spray residues can have quite good longevity in rain with Du-Wett addition (Gaskin *et al.* 2011a), whereas a product like Serenade Max may be less rainfast and benefit from the use of DW-RM to rainfasten sprays.

The mean release height of sprays was lowest in this study, at 12 m compared to 26 m in Study 1 and 18 m in Study 2 (Appendix 2). Mean leaf deposits for the top canopy zone were 1.2, 1.9 and 2.0 µg/cm^2 for Studies 1, 2 and 3, respectively, confirming a possible relationship between on-target deposits and release height of sprays (Fig. 7). This should be confirmed by quantifying spray deposits from applications made by a smaller helicopter (e.g. Robinson 44), which can fly at much lower release heights than the Squirrel used in these studies. It is presumed that the higher release height may predispose sprays to drift more, even under calm wind conditions, due to rotor wash from the helicopter. The drift potential of aerial sprays was quite evident in many of the photographs taken during the three studies reported here (Appendix 3).

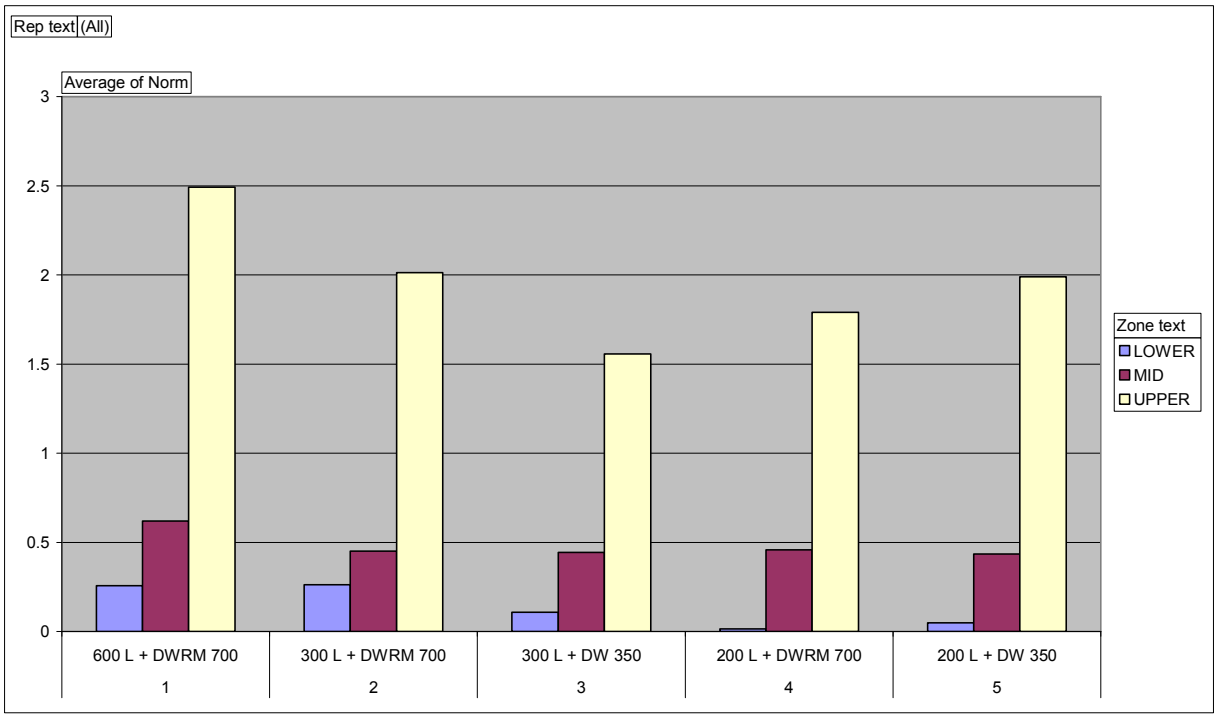

Fig. 5: Aerial spray deposits on foliage in the lower, mid and upper canopy zones on a Hayward pergola.

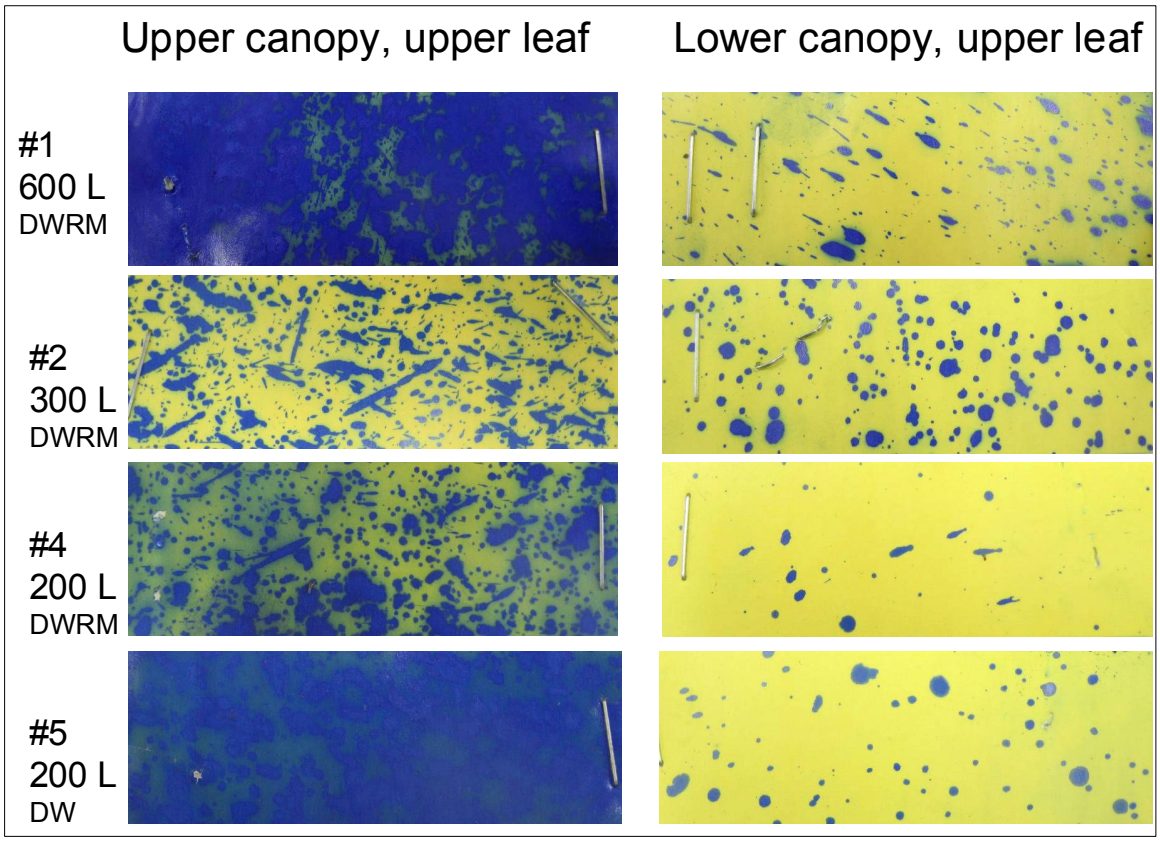

Fig. 6: Water sensitive papers showing typical highest spray deposits intercepted on the upper exposed side of leaves in the top and lower canopy zones.

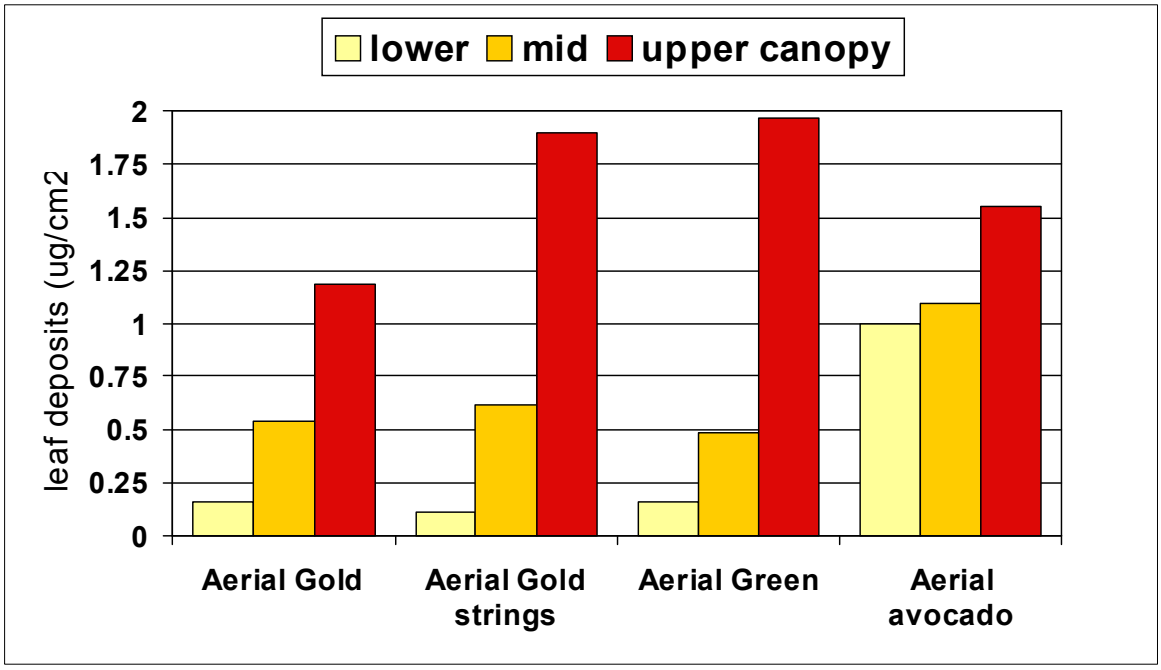

Fig. 7: Comparison of mean leaf deposits from Studies 1, 2 & 3 and an aerial spray application to avocados

CONCLUSIONS

- Leaves in the top canopy zone of a Hayward pergola, directly exposed to aerial sprays, received 75% of spray deposited on the canopy.

- Leaves in the sheltered mid and lower canopy zones received much lower deposits, of 18% and 6% of total canopy deposits, respectively. No spray was deposited on fruit.

- Low volume (200 & 300 L/ha) sprays provided up to 36% lower mean spray deposits than a 600 L/ha spray.

- The use of Du-Wett adjuvant resulted in better spray coverage of leaf surfaces than DW-RM, and at half the cost, but Du-Wett lacks the rainfastening ability of DW-RM.

- Further evidence was observed that lower release heights of sprays may result in less drift and higher on-target deposits.

GENERAL DISCUSSION

The mean deposits on lower and mid canopies were similar and poor on all three canopies measured in these studies (Fig. 7). The comparison with aerial sprays (applied at 600, 300 & 200 L/ha) on 12 m tall avocado trees (Gaskin *et al.* 2011b) demonstrates the limiting effect of the pergola structure on deposits on kiwifruit canopies. While mean deposits on exposed leaves in the top of a kiwifruit canopy could be similar to those on the exposed top of large avocado trees, the deposits on mid and lower zones on avocado trees were much higher than on kiwifruit. This is presumed due to the comparatively less dense and non-continuous canopy in an avocado orchard and the positive effects of downward rotor wash from the helicopter on moving spray through the tree canopy. This is in contrast to the 'tiling' effect of the rotor wash on leaves on the top of a kiwifruit pergola, which creates a substantial barrier to spray penetration into the canopy.

A comparison of aerial and ground applied spray deposits on kiwifruit canopies is presented in Fig. 8. The ground applied sprays were from an airblast application made at 1000 L/ha (with addition of Du-Wett adjuvant) to early season, relatively light, green and gold canopies. The canopy zones are not directly comparable because of the differences in sampling methods; the ground based study upper zone sample was any leaf in the upper canopy shaded from the sprayer and hence may be more equivalent to a mid-canopy zone in the aerial study. It was usually not sampled from the topmost leaves which would be exposed to an aerial spray. Thus, these results are likely to indicate the highest possible deposits which could be achieved on leaves in the top canopy zone from an airblast spray. In reality the deposits may be much less. Additionally the airblast spray results provide no information on the relative deposits on upper and lower leaf surfaces. As the airblast deposits on the upper canopy zone are at best equivalent to the aerial spray deposits (Fig. 8), this suggests that aerial sprays will provide higher spray deposits on leaves in the top of dense, pre-harvest, pergola canopies, and certainly better deposits on upper leaf surfaces. This should be confirmed in airblast spray deposit studies.

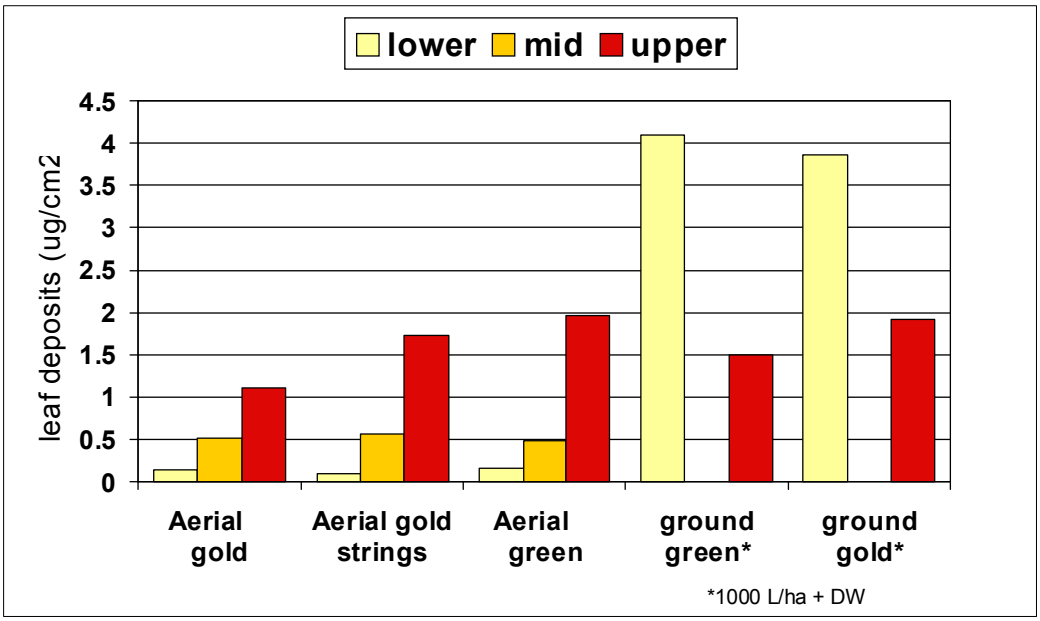

Fig. 8: A comparison of mean leaf deposits from aerial and ground (1000 L/ha) sprays applied to kiwifruit.

OVERALL CONCLUSIONS

- **Aerial sprays do not penetrate well into any pergola canopies and only target leaves on the top of the canopy; these intercept ca 70% of an aerial spray.**

- **The undersides of leaves are poorly targeted by aerial sprays.**

- **No aerial sprays were deposited on fruit, thus such operations, on dense, pre-harvest canopies, are unlikely to contribute to chemical residues.**

- **Generally, low volume (200 L/ha) sprays performed similarly to higher volume (600 L/ha) sprays and are justified on the basis of cost.**

- **There was some evidence that aerial spray deposits on pergola canopies can be increased by reducing the flight height and presumably, also reducing off-target drift.**

- **Du-Wett Rainmaster adjuvant can be used to rainfasten sprays on upper surfaces of leaves; it should be added to aerial sprays at 700 ml/ha to ensure good coverage of leaf surfaces.**

- **Du-Wett adjuvant should be used preferentially (350 ml/ha), to minimise costs, when rainfastening of sprays is not required.**

- **Limited comparisons with deposits from airblast sprays suggest aerial sprays will provide better protection to foliage, primarily the topside of leaves, on the top of pergola canopies.**

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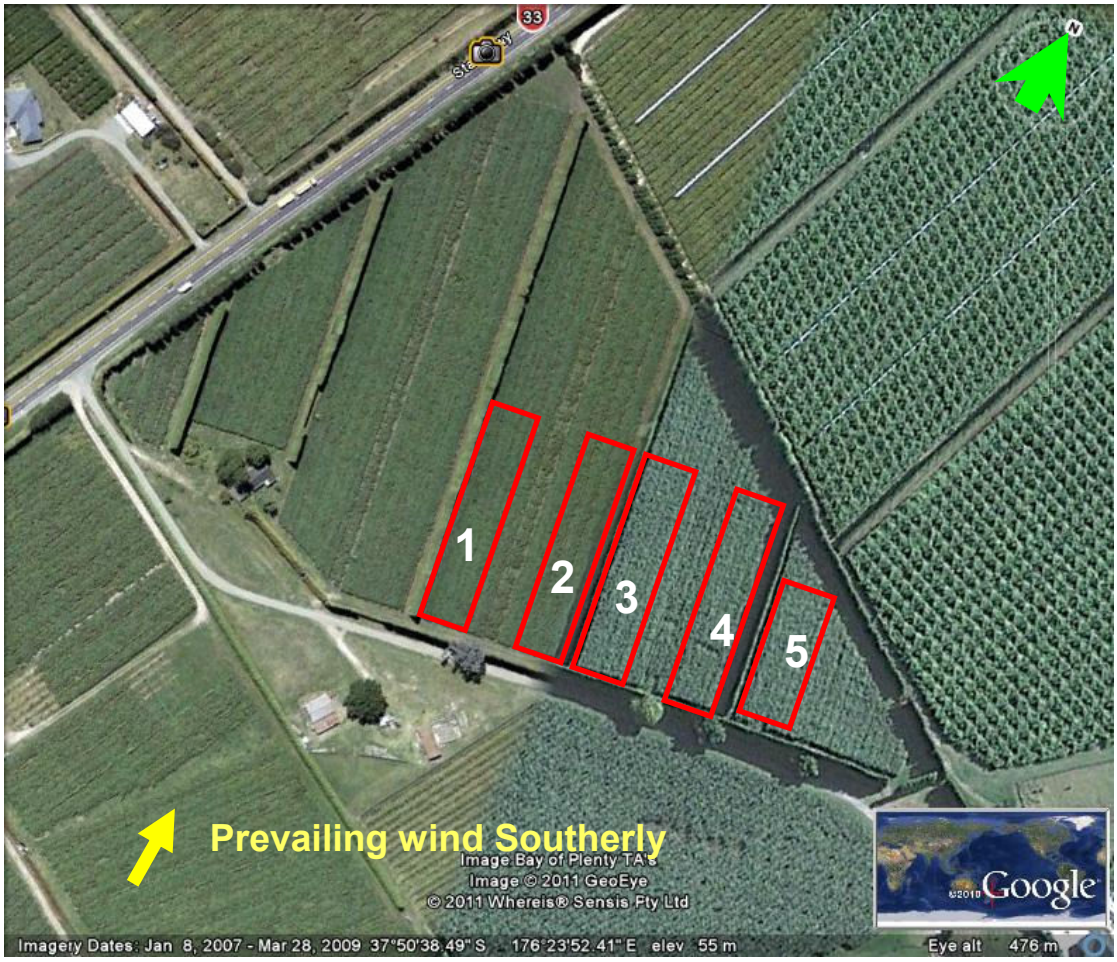
APPENDIX 1
Photographs of trial sites showing treatment blocks

Study 1: PE Christiansen's orchard, 443 SH 33, Te Puke

Study 2: Longview Trust Orchard, 443 SH 33, Te Puke

Study 3: Phil Leppard's orchard, 499 SH 33, Te Puke



APPENDIX 2
Weather conditions and mean aerial application (flight) height

Study 1

Tmt	Mean Flight Ht (m) above ground	Air Pressure HPA	Air Temp.	Humidity	Wind Speed km/hr	Wind Direction
1	26	1020	16	62	5	South
2	27	1020	16	62	5	South
3	27	1020	17	62	5	South
4	24	1020	17	62	5	South
5	24	1020	17	62	5	South

Study 2

Tmt	Mean Flight Ht (m) above ground	Air Pressure HPA	Air Temp.	Humidity	Wind Speed km/hr	Wind Direction
1	21	1019	17	68	12	South
2	14	1019	17	69	15	South
3	17	1019	17	68	15	South
5	20	1020	18	68	18	South

Study 3

Tmt	Mean Flight Ht (m) above ground	Air Pressure HPA	Air Temp	Humidity	Wind Speed km/hr	Wind Direction
1	11	1022	20	57	5	South
2	14	1022	20	57	5	South
3	12	1022	20	57	5	South
4	11	1022	20	57	5	South
5	11	1022	20	57	5	South

APPENDIX 4: Photos

Study #1

Canopy close-up

Shade cloth barriers around blocks

Spray application 200 L/ha (Tmt 4)

Hort 16 A canopy

Spray application 200 L/ha (Tmt 5)

Study #2: Spray application to strung canopy

Hort 16A Strung canopy

Hort 16A strung canopy (underside) from below

Spray application 300 L/ha; note pressure waves in spray

Study #3: Spray application 600 L/ha (Tmt 1)

Spraying at 300 L/ha (Tmt 2)

Spraying at 200 L/ha (Tmt 4)

Spraying at 200 L/ha (Tmt 5)

200 L/ha (Tmt 5)

Plant Protection ChemistryNZ Ltd is an independent provider of research, advisory and extension services relating to the use and efficacy of agrichemicals.

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