Report to KVH/ZESPRI Psa R&D Programme

Assessment of novel spray units for use in kiwifruit orchards

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Plant Protection Chemistry NEW ZEALAND

EXECUTIVE SUMMARY

This study was undertaken to compare three novel sprayer units (low volume Electrostatic, Silvan split air boom and Quantum Mist multi-headed axial fan) against an industry standard, axial fan, airblast sprayer (Atom), to determine if any of the novel sprayers could provide an incremental improvement in coverage of kiwifruit canopies with protectant sprays. The performance of the sprayers, with respect to spray coverage on foliage and spray distribution throughout the canopy, was compared on a pruned Hayward canopy containing dense, un-pruned male vines and a pruned Hort 16A pergola orchard, in early summer of 2011.

In summary:

The sprayers

- No sprayer showed a markedly superior performance to the others.
- Deposits and deposit variability from the Atom, Silvan and Quantum Mist sprayers were comparable.
- The Atom sprayer tended to achieve the highest average deposits.
- Deposits from the Electrostatic sprayer tended to be lower than those from the other sprayers and showed the greatest deposit variability on canopy zones.

Canopy effects on deposits

- The variation in deposits was greater between canopy zones than between sprayers, indicating that the canopy is the primary factor affecting deposit levels.
- This implies that canopy management is likely to be of greater importance in Psa control than the type of sprayer used.
- Deposits in dense upper male canopy zones were significantly lower across all of the sprayers and spray volumes tested. Dense canopy zones are difficult to treat with any sprayer.
- All sprayers tested in this study are likely to provide satisfactory spray coverage on canopies that are managed to minimise density, but the effects of varying canopy density must be quantified to factor into guidelines for sprayer setup.

Dilute versus concentrate sprays

- Deposits from both dilute and 2x concentrate application volumes were comparable.

- These tests have indicated that higher deposits can be achieved from concentrate sprays in regular open canopies.

- Canopy management may allow even more concentrated sprays to be used for greater spraying efficiency.

PPC NZ Plant Protection Chemistry NEW ZEALAND

Assessment of novel spray units for use in kiwifruit orchards

INTRODUCTION

Sprayer technology for kiwifruit orchards is based on airblast application and has served the industry well until now. The arrival of Psa has changed the requirement for sprayer performance; protectant sprays are now required to cover all foliage. Novel spray technologies exist in other crops which have not been utilised in kiwifruit. Growers were generally not proactive in introducing new technologies while traditional airblast sprayers performed adequately in the pre-Psa environment. Even now that optimum sprayer performance is considered essential, growers are understandably unwilling to take the risk of introducing unproven new technology if there is the possibility it may not perform and compromise the survival of their orchards.

KVH/ZESPRI are very aware of the need to move the kiwifruit industry towards better and more efficient spraying programmes to control Psa. As a result they commissioned this comparative study of three novel sprayer units (low volume Electrostatic, Silvan split air boom and Quantum Mist multi headed axial fan) against an industry standard, axial fan, airblast sprayer (Atom). The intent was to determine if any of the novel sprayers could provide an incremental improvement in coverage of kiwifruit canopies with protectant sprays.

The performance of the four sprayers, with respect to spray coverage on foliage and spray distribution throughout the canopy, was compared on both a dense Hayward and a pruned Hort16A pergola orchard, in early summer of 2011.

METHODS AND MATERIALS

The studies were undertaken on 6-9th December 2011. The first two days were used for preliminary orchard trials, utilising water sensitive papers (WSP) extensively and limited deposit analyses, to select and calibrate the most promising sprayer setups. The full deposit studies were undertaken on the 8th and 9th of December.

Orchards

Study 1 was undertaken on Cook's Ranfurly Orchard (Hayward) at Huse Lane (Photograph 1). This was pergola trained on 5 m row spacing. Female vines were pruned with an estimated mean leaf area index (LAI) of 2.4-4.8 in the centre of rows and 1.5-4.2 at the female leader (Appendix 1). Each row (and each sampling bay) contained a leader zone section of un-pruned male vine with an estimated mean LAI in the leader zone of 5.4-9.4 and a mean canopy depth of up to 1 m (Appendix 1).

The second study was undertaken on Straun's Pencam orchard (Hort 16A) at 178 Te Matai Rd, (Photograph 2). This was pergola trained on 4.4 m row spacing. Female vines were pruned with an estimated LAI of approximately 2.8-4.8 in the centre row and 2.6-3.8 at the leader (Appendix 1). Some vine extension growth was present above the entire canopy; at the leader these extended a mean height of approx. 1.3 m (max. of 3 m) above the pergola wires. Each row contained male vines from which all foliage had been removed, resulting in frequent 'gaps' in the canopy. Treatment bays were selected to avoid male vines.

The centre row canopy was slightly less dense in the Hayward than in the Hort 16A orchard (Appendix 1), but was more uniform with fewer gaps. Excluding the presence of un-pruned males, the pruned leader zones were of similar density in both orchards, but the wider row spacing of the Hayward orchard made the (female) leader foliage a more difficult target in this variety. The dense un-pruned male vines in the Hayward orchard presented an extremely difficult spray target (Photograph 1).

Photograph 1: Hayward canopy

Sprayers and sprayer setups

Four different spray application technologies were compared in these experiments. A modern axial fan airblast sprayer was selected as a current industry standard for comparison with three novel application technologies (Table 1).

Table 1: Sprayer descriptions and details (for more detail see Appendix 2)

Sprayer Make	Description	Fan type	Nozzling
Atom 2000 turbo Evo Modena	Axial fan airblast Industry standard	Front entry fan 910 mm diameter Kiwifruit straightening vanes	Using front ring of two. 5 & 6 nozzles per side in 4.4 & 5 m rows respectively. Using Albuz ATR and TeeJet ceramic disk and core cone nozzles.

Sprayer Make	Description	Fan type	Nozzling
Silvan kiwifruit sprayer	Eight directed split air delivery heads fitted to a boom	Centrifugal PTO driven fan with ducting to split air output heads	Two ATR equivalent ceramic hollow cone nozzles per head. Using 8 nozzles per side.

Table 1: Sprayer descriptions and details (continued)

Sprayer Make	Description	Fan type	Nozzling
Croplands Kiwi Quantum	Trial sprayer fitted with 3x QM500 heads to treat half a row per pass	Direct throughput 500 mm diameter hydraulically driven axial fan	Eight Albuz ATR hollow cone nozzles per head. Using 24 nozzles per side.

Sprayer Make	Description	Fan type	Nozzling
ESS Electrostatic sprayer	Trial sprayer fitted with 28 ESS nozzles in a twin boom arrangement	Supercharger fan ducted to nozzles – high velocity, low volume air used to form and project spray droplets	Low volume air shear nozzles. Sprayer run with 18 nozzles per side in 5 m rows and 14 nozzles per side in 4.4 m rows.

The industry standard Atom airblast sprayer was selected as representative of the best expected spray delivery and performance of the range of airblast sprayers currently used in the NZ kiwifruit industry. This sprayer was calibrated using currently accepted industry standard nozzle output configurations (Appendix 2) for treating pergola canopies on 4.4 and 5 m row spacings. A travel speed of ca. 6 km/h was selected for these tests as representative of currently accepted industry standard practice for in-season protectant spray applications. The Atom, Silvan Kiwifruit and Croplands Kiwi Quantum sprayers were fitted with spray controllers that adjusted operating pressures in relation to slight variations in travel speed to maintain the target spray application volumes of 500 and 1000 L/ha on both canopies (application details in Table 2). The Atom and Silvan Kiwifruit sprayers were configured to spray full rows in each pass. The Croplands Kiwi Quantum sprayer used in these experiments was a trial plot sprayer that was configured to treat half row sections in each pass.

The ESS electrostatic sprayer boom had sufficient nozzles to treat a full row in a single pass on 4.4 m row spacings (14 nozzles per side), but was used to treat half row sections (18 nozzles per side) in the block on the 5 m row spacing. The ESS sprayer was completely new technology to the kiwifruit industry and, as a result of tests of penetration and coverage before the main deposit experiments, was run at travel speeds below 6 km/hr in all but one of the deposit tests to ensure that the sprayer output had maximum opportunity to penetrate and deposit in the target canopies.

Air output volumes from the Atom sprayer were visually adjusted to match spray plume penetration to the density of the two different canopy spray targets, with slightly lower air outputs used in the less dense Hort 16A canopy (Appendix 2). There were no direct changes to the air outputs from the three novel sprayers for the different canopies.

The travel speed and output volumes for each sprayer were calibration checked prior to application at each site. Prior to each spray deposit test, each sprayer made an application pass in a representative section of canopy to allow nozzle output orientations to be checked and adjusted to maximise potential spray coverage and even output distributions in target canopies. The only significant changes to the base nozzle configuration of the sprayers was made with the ESS sprayer after the first deposit test. In this case it was decided that the nozzles appeared to perform better at a greater distance away from the canopy (nozzle tip to first canopy separation increased from ca. 400 mm to ca. 600 mm) and nozzle orientations relative to the direction of travel were altered to give a greater backward angle to the nozzles on the trailing boom (angle increased from ca. 20^{o} to ca. 35^{o} away from the direction of travel).

Treatments

Two treatments were applied by each sprayer (Table 2) on each orchard. The only exception was that Tmt 5 (Quantum Mist, dilute spray) in Study 1 was not sampled due to an error in its application. Sprayer travel speed was approx. 6 km/h for all spray applications except those of the ESS, where travel speeds from 4-6 km/h were tested.

Adjuvant (Du-Wett superspreader, Etec) was included in all treatments at 400 ml/ha, except in the ESS treatments; thus the adjuvant concentration in these spray mixtures increased with decreasing application volumes (0.04 and 0.08% for spray volumes of 1000 and 500 L/ha respectively). The adjuvant was included in the ESS treatments at 120-240 ml/ha (constant at 0.1% concentration). The adjuvant addition with the ESS sprayer was found to (desirably) increase the charge on ESS droplets.

No pesticide was included in any treatment as commercial pesticides generally have little or no effect on the physical properties of sprays containing Du-Wett (data not presented). The non-hazardous fluorescent dye, Pyranin 120% (Lanxess, ex Bayer NZ) was included as a tracer to measure deposits in all treatments, at 5-20 g/ha. All treatments were applied between 10 am and 5 pm in warm, moderately calm conditions on both days. The orchard blocks were well sheltered and mean wind speed above the canopy was < 0.3 m/s in Study 1 and ca 0.6 m/s in Study 2 (Appendix 3).

Photograph 2: Hort 16A canopy

Table 2: Treatments applied to Hayward and Hort 16A canopies

Tmt #	Sprayer	Spray volume (L/ha)	Travel speed (km/h)	Adjuvant rate ml/ha (%)
1	Atom	1000	6.0	400 (0.04)
2		500	6.0	400 (0.08)
3	Silvan	1000	6.0	400 (0.04)
4		500	6.0	400 (0.08)
5	Quantum Mist	1000	6.0	400 (0.04)
6		500	6.0	400 (0.08)
7	ESS	200	5.0	200 (0.1)
8		240	4.2	240 (0.1)
7[1]	ESS	150	5.0	150 (0.1)
8[1]		120	6.2	120 (0.1)

[1]Tmt 7&8 as applied on the Hayward orchard (Study 1), the repeat data is as applied on the Hort 16A orchard (Study 2)

Spray application and foliage sampling

Two replicate block applications were made for each treatment on each orchard, with each treatment applied to three bays in each of three adjacent rows. All deposit samples were taken from the centre bay in the 3x3 bay grid.

After spray treatments had dried, leaf samples were collected from the centre bay in each replicate block. In Study 1 (Hayward) samples were taken from five different canopy zones in each treatment bay; upper (leaves in top of canopy shielded from sprayer) and lower (exposed to sprayer) positions at the row centre, randomly from throughout the female (pruned) leader zone (within one wire either side of the vine), and from the lower (exposed to sprayer) and upper (fully shielded) positions on the dense un-pruned male leader zone.

In Study 2 (Hort 16A) samples were taken from five different canopy zones in each treatment bay; upper (leaves in top of canopy shielded from sprayer) and lower (exposed to sprayer) positions at both the row centre and the female leader zone, and from the new growth expanding rapidly above the leader zone (approx 2.25 m above ground).

Two replicate samples of five random leaves each were collected in each zone from each replicate block, placed in resealable plastic bags and kept out of direct sunlight. They were washed within 20 mins of harvest to recover dye with 400 ml water containing 0.025% Du-Wett. Prior audits confirmed >90% dye recovery from leaves within this time period. Spray deposits were quantified using a fluorimeter, and leaf areas were determined with a Leaf Area Meter. Deposits were calculated as dose ($\mu g/cm^2$) and were normalised to an equivalent spray application rate of 1 kg a.i. per ha in each treatment (to allow meaningful direct comparisons of deposits between treatments). The deposit data were presented as micrograms of tracer per square centimetre of projected (one-sided) leaf area. True average deposit per square centimetre of top and bottom leaf surface is theoretically half of this figure, but deposits on top and bottom leaf surfaces may vary widely (Gaskin *et al*. 2011). Results were statistically analysed using ANOVA to determine the significance of treatment on spray deposits retained on leaves in different zones.

Water sensitive paper (WSP) studies

WSPs were placed on leaves within the centre bay of a single block (Rep 1) for each treatment to visually record deposits. Papers (37 x 25 mm) were pinned to leaf midribs on corresponding upper and lower surfaces of five replicate leaves in four different canopy zones for each orchard study. In Study 1 (Hayward) these were the centre lower, centre upper, male leader lower and dense male leader upper zones. In Study 2 (Hort 16A) these were the centre lower, centre upper, (female) leader lower and (female) leader upper zones.

RESULTS AND DISCUSSION

Quantitative deposit study

The mean deposits from the standard sprayer (Atom) applying dilute and concentrate sprays (Tables 3&4) were similar to those achieved previously on un-pruned autumn/spring canopies (Gaskin *et al*. 2011). Average (mean) leaf deposit levels of ca. 1.5-2.5 $\mu g/cm^2$ can usually be expected from application of 1 kg of chemical per hectare to a canopy with a leaf area index of approx. 3. The mean spray deposits from all four sprayers in these trials were in line with expected deposit levels, with no sprayer showing exceptionally high or low deposits. Mean deposits from the Atom were at the high end of the expected level and were overall the highest achieved by any sprayer on both canopies (Figs 1&2). Mean deposits from the Silvan and Quantum Mist were generally similar. Mean deposits from the ESS tended to be lower and were significantly reduced on the Hort 16A canopy when sprayer speed was increased from 5.0 to 6.2 km/h (Table 4).

Mean deposits from sprayers on both canopies were surprisingly similar (cf Figs 1 &2), but examination of separate zones (leader, centre row, upper canopy, lower canopy) showed considerable variation between and within sprayers (Tables 3&4). The deposits on leader zones, particularly on the pruned Hort 16A canopy, were higher overall than seen previously with the Atom sprayer on an un-pruned pergola canopy in autumn (Gaskin *et al*. 2011). Leader deposits were generally similar to centre row deposits in the Hayward canopy (Table 3, Fig 3), which was surprising considering the dense un-pruned males in the leader zone. In contrast, the leader zone of the fully pruned Hort 16A canopy generally received higher deposits than the centre of rows (Table 4, Fig 4) These results reflect the lower density of the leader zone. Pruning appears to have had an effect on deposits but this requires quantifying in a structured canopy study. The variation in proportion of spray deposited on leader and centre zones in both canopies (Figs 3&4) presumably reflects individual sprayer setup.

Table 3: Mean deposits (μg/cm^2, normalised to a 1 kg/ha application of dye) on Hayward canopy, from sprays applied by four different sprayers (Study 1).

Sprayer	Treatment description L/ha, km/h	Canopy zone		Canopy position		Tmt
		Leader	Centre	upper	lower	mean
Atom dil	1000, 6	2.0 bcd	2.3 ab	0.9 f	3.4 b	2.3 AB
Atom conc	500, 6	2.6 a	2.0 bc	0.7 fg	3.9 a	2.6 A
Silvan dil	1000, 6	1.3 ef	2.4 ab	0.7 fg	3.0 bc	2.1 BC
Silvan conc	500, 6	1.7 cde	1.7 cde	0.5 fg	2.9 cd	1.8 CD
QMist dil	1000, 6	-	-	-	-	-
QMist conc	500, 6	1.5 ef	2.1 abc	0.7 fg	2.9 bcd	2.0 C
ESS-1	200, 5	1.6 de	1.3 ef	0.4 g	2.5 d	1.6 DE
ESS-2	240, 4.2	1.0 f	1.4 ef	0.6 fg	1.9 e	1.4 E
Mean		1.7 B	1.9 A	0.6 B	2.9 A	

Means within each coloured table sharing common postscripts are not significantly different (LSD, P=0.05).

Table 4: Mean deposits (μg/cm^2, normalised to a 1 kg/ha application of dye) on Hort 16A canopy, from sprays applied by four different sprayers (Study 2).

Sprayer	Treatment description L/ha, km/h	Canopy zone		Canopy position		Tmt
		Leader	Centre	upper	lower	mean
Atom dil	1000, 6	2.6 ab	1.8 ef	1.7 ef	2.7 bcd	2.2 B
Atom conc	500, 6	3.0 a	2.2 bcd	1.8 e	3.5 a	2.6 A
Silvan dil	1000, 6	2.2 bcde	1.9 def	1.4 efg	2.8 bcd	1.9 CDE
Silvan conc	500, 6	2.3 bcd	1.6 fg	1.3 fg	2.5 cd	1.9 BCD
QMist dil	1000, 6	2.1 cde	1.3 g	1.1 g	2.3 d	1.6 EF
QMist conc	500, 6	2.5 bc	2.0 def	1.5 efg	3.0 bc	2.2 BC
ESS-1	150, 5	2.0 def	2.3 bcd	1.1 g	3.1 ab	1.8 DE
ESS-2	120, 6.2	1.3 g	1.9 def	0.5 h	2.7 cd	1.4 F
Mean		2.2 A	1.9 B	1.3 B	2.8 A	

Means within each coloured table sharing common postscripts are not significantly different (LSD, P=0.05).

The typical lower:upper canopy deposit ratio in kiwifruit is 2:1 (Gaskin *et al*. 2010, 2011). This ratio was generally maintained with most sprayers on the pruned Hort 16A canopy (Table 4, Fig 6), but not on the Hayward canopy (Table 3, Fig. 5) due to the very dense un-pruned male vines. Leaves in the lower canopy position always received highest deposits, regardless of sprayer (Tables 3&4), and were often over-sprayed (Figs 5&6), while upper canopy foliage always received lowest deposits. This is dictated by canopy structure and is unlikely to be modified by sprayer setup. The ESS showed the least penetration of spray to the upper canopy zone when the sprayer operated at the highest speed (Fig. 6).

Mean deposits on individual canopy zones are presented in Tables 5&6. They confirm the variation in deposits was greater between canopy zones than between sprayers (see Figs 7&8). In the Hayward canopy, the upper canopy foliage in both the dense male leader zone and the centre row were poorly targeted by all sprayers (Fig. 7). In the Hort 16A canopy, the centre row upper canopy was similarly poorly targeted while the leader zone upper canopy received much higher deposits (Fig. 8). With not dissimilar canopy densities (LAI) at the leader and centre row, this suggests that sprayer setups were targeting the leader zone at the expense of the centre row upper canopy.

The differences in canopy density between the leader zone and row centres in the Hort 16A block were visibly apparent when the sprayers were being setup for the trial. However, the differences were not considered sufficiently large enough to attempt to change nozzle output distributions from normal industry practice. Industry experience, particularly with scale control, has found that the leader zone is usually the most difficult to spray and standard industry calibration practices tend to focus on nozzling and sprayer setup to treat the leader zone. The canopy in the row centre is usually closest to the sprayer and historically has been the easiest to treat. Kiwifruit canopies show large between and within block variations in canopy density. Unfortunately the industry does not currently have sophisticated tools, that can quickly and accurately prescribe sprayer set-up (including volumes and rates) in response to varying canopy densities, available to assist spray applicators in adjusting set-ups to achieve complete coverage of canopies. The deposit data from this and other trials is expected to contribute to developing guidelines for sprayer setup that factor in canopy density.

A brief discussion on the sprayers tested in this study and considerations for their use in kiwifruit is presented in Appendix 2.

Table 5: Mean deposits (μg/cm^2, normalised to a 1 kg/ha application of dye) on individual Hayward canopy zones, from sprays applied by four different sprayers (Study 1).

Sprayer	Treatment description L/ha, km/h	Canopy zones: Centre lower	Centre upper	Female leader	Male leader lower	Male leader upper
Atom dil	1000, 6	3.2	1.4	3.1	3.5	0.4
Atom conc	500, 6	3.3	0.8	4.0	4.6	0.6
Silvan dil	1000, 6	3.6	1.1	3.2	2.3	0.3
Silvan conc	500, 6	2.7	0.7	2.4	3.0	0.4
QMist dil	1000, 6	-	-	-	-	-
QMist conc	500, 6	3.5	0.8	2.6	2.3	0.6
ESS-1	200, 5	1.9	0.6	2.2	3.0	0.2
ESS-2	240, 4.2	2.0	0.9	2.3	1.7	0.3
Mean		2.9 A	0.9 B	2.8 A	2.9 A	0.4 C

LSD(P=0.05) critical value for comparison of means within main table = 0.8.
Canopy zone means sharing common postscripts are not significantly different (LSD, P=0.05).

Table 6: Mean deposits (µg/cm^2, normalised to a 1 kg/ha application of dye) on individual Hort 16A canopy zones, from sprays applied by four different sprayers (Study 2).

Sprayer	Treatment description L/ha, km/h	Canopy zones				
		Centre lower	Centre upper	Female leader lower	Female leader upper	Female leader tops
Atom dil	1000, 6	2.4	1.2	3.1	2.2	2.3
Atom conc	500, 6	3.3	1.2	3.7	2.3	2.3
Silvan dil	1000, 6	2.7	1.1	2.8	1.6	1.2
Silvan conc	500, 6	2.2	0.9	2.9	1.6	2.0
QMist dil	1000, 6	1.9	0.7	2.7	1.5	1.1
QMist conc	500, 6	2.7	1.2	3.2	1.8	1.9
ESS-1	150, 5	3.6	0.9	2.7	1.3	0.7
ESS-2	120, 6.2	3.2	0.6	2.1	0.5	0.4
Mean		2.7 A	1.0 C	2.9 A	1.6 B	1.5 B

LSD(P=0.05) critical value for comparison of means within main table = 0.7.
Canopy zone means sharing common postscripts are not significantly different (LSD, P=0.05).

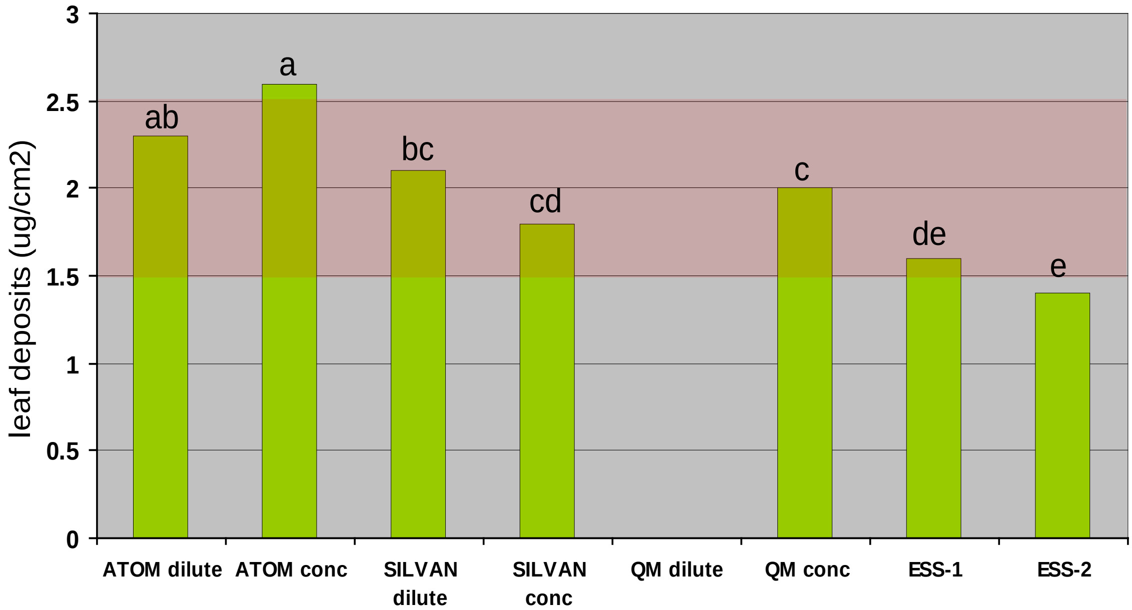


Fig. 1: Mean deposits (µg/cm^2) on Hayward canopy (Study 1) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test).
Quantum Dilute tmt data is unavailable in this study due to an application error in the field trial.

The red shaded band on Figs 1-8 (between 1.5-2.5 µg/cm^2 deposits) indicates typical normalised deposit levels expected on a kiwifruit pergola canopy of this density from spray applications providing "acceptable" coverage of leaf surfaces. Note that individual deposits within treatments may vary widely and fall outside of this range.

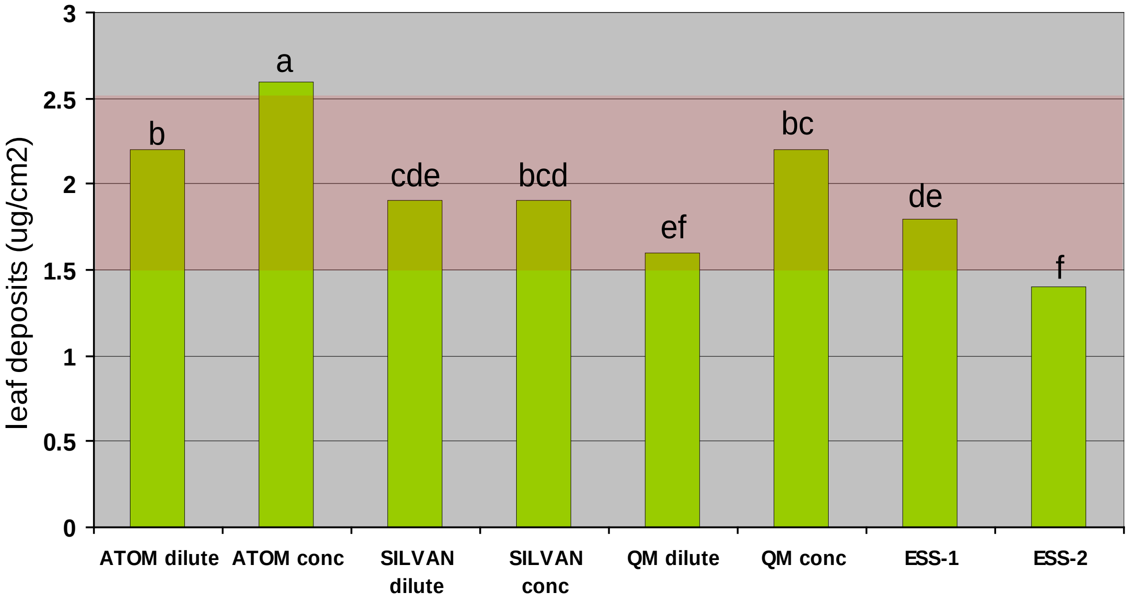


Fig. 2: Mean deposits (µg/cm^2) on Hort 16A canopy (Study 2) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test)

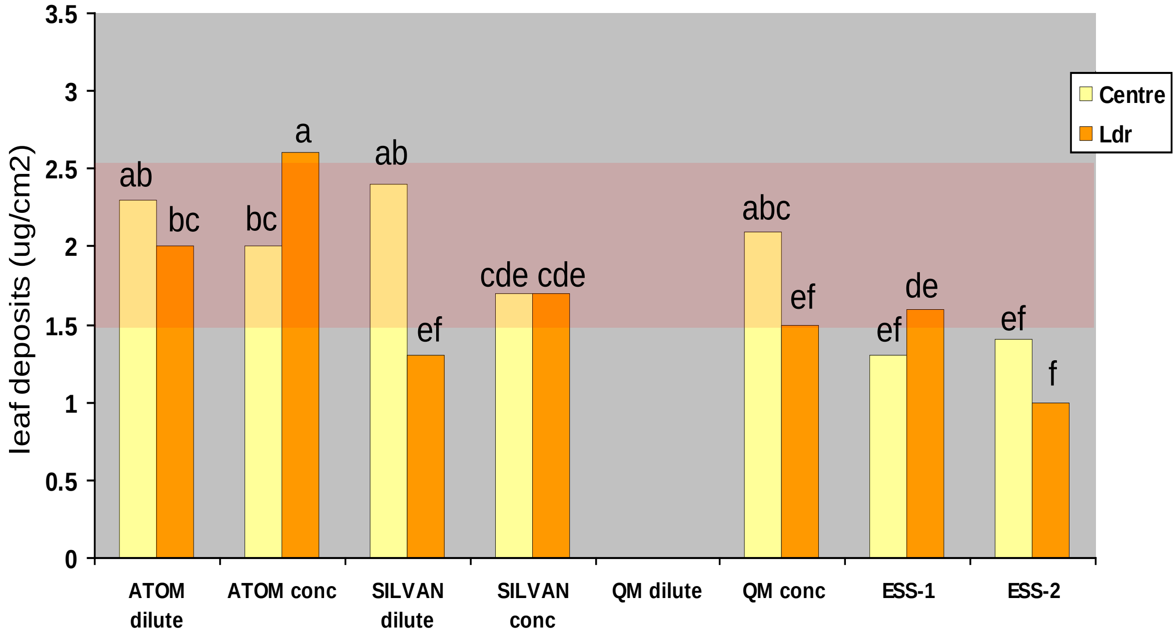
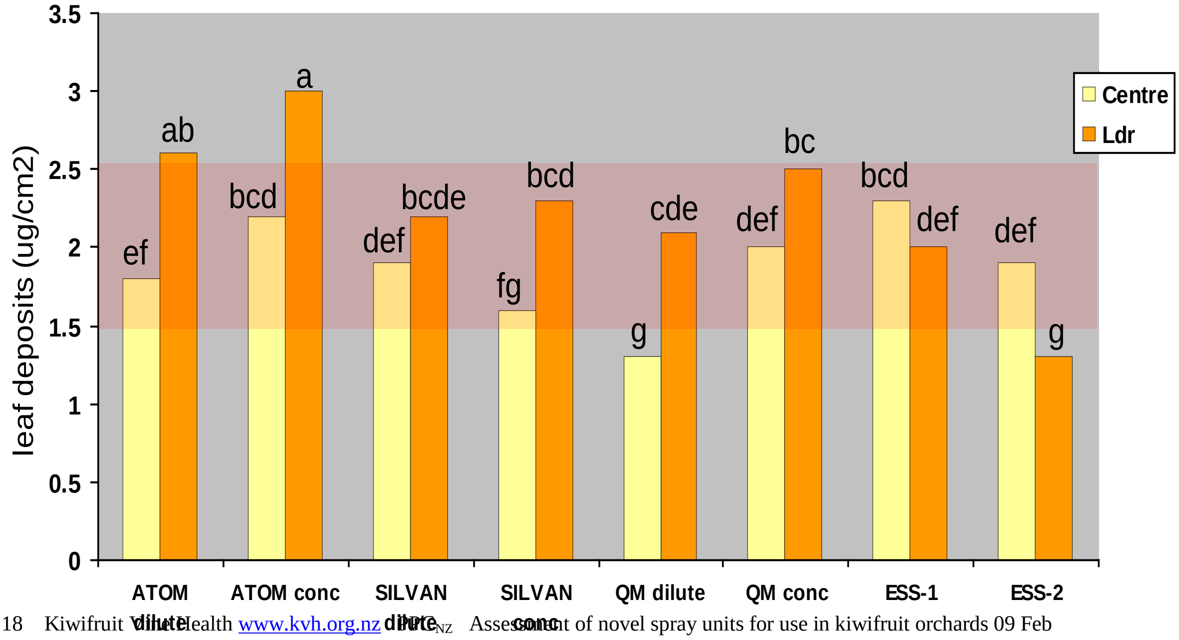


Fig. 3: Mean deposits (µg/cm^2) on centre and leader zones of Hayward canopy (Study 1) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test).
Quantum Dilute tmt data is unavailable in this study due to an application error in the field trial.

Fig. 4: Mean deposits (µg/cm^2) on centre and leader zones of Hort 16A canopy (Study 2) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test).



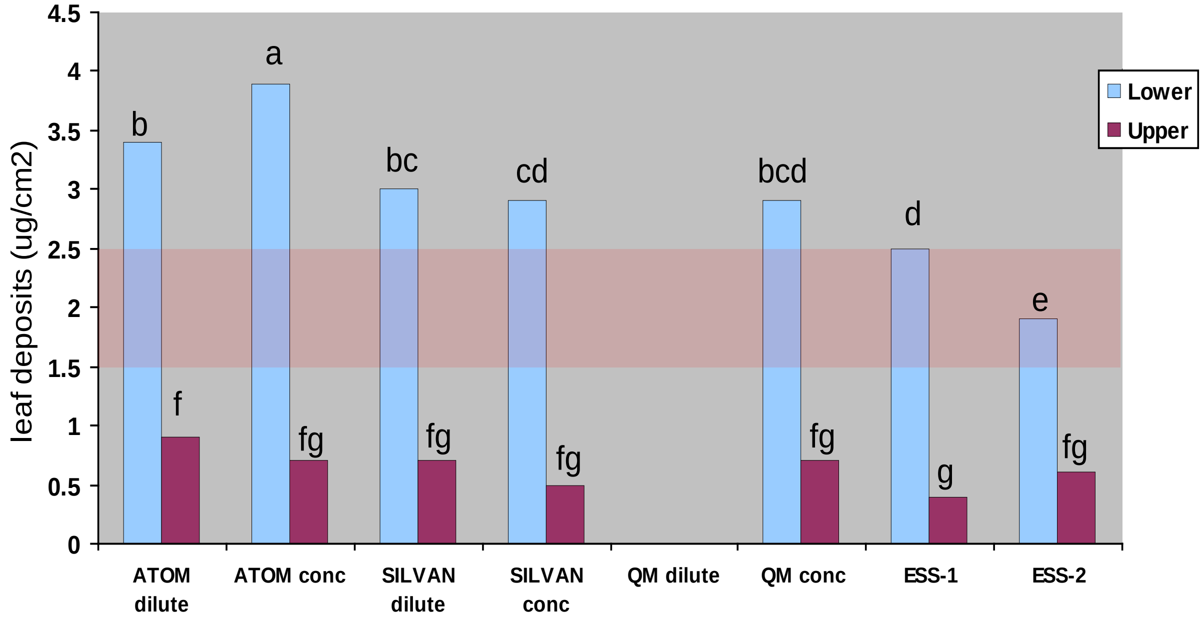


Fig. 5: Mean deposits (μg/cm^2) on lower and upper zones of Hayward canopy (Study 1) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test).
Quantum Dilute tmt data is unavailable in this study due to an application error in the field trial.

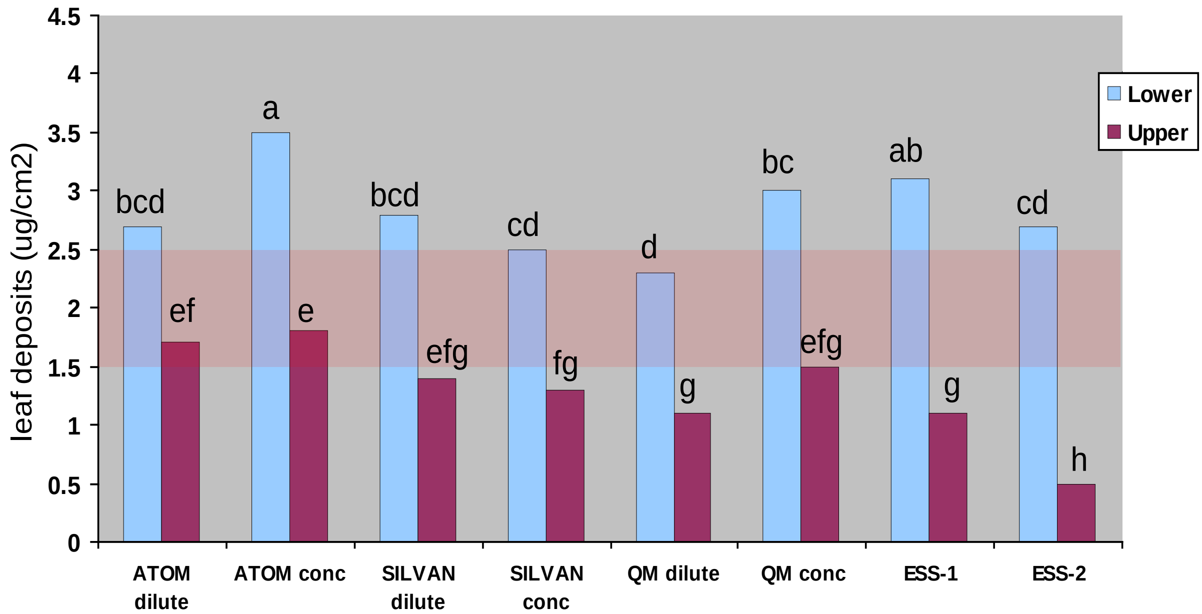


Fig. 6: Mean deposits (μg/cm^2) on lower and upper zones of Hort 16A canopy (Study 2) from a normalised application of 1 kg/ha dye in each treatment

Means sharing common letters are not significantly different (P0.05, LSD test).

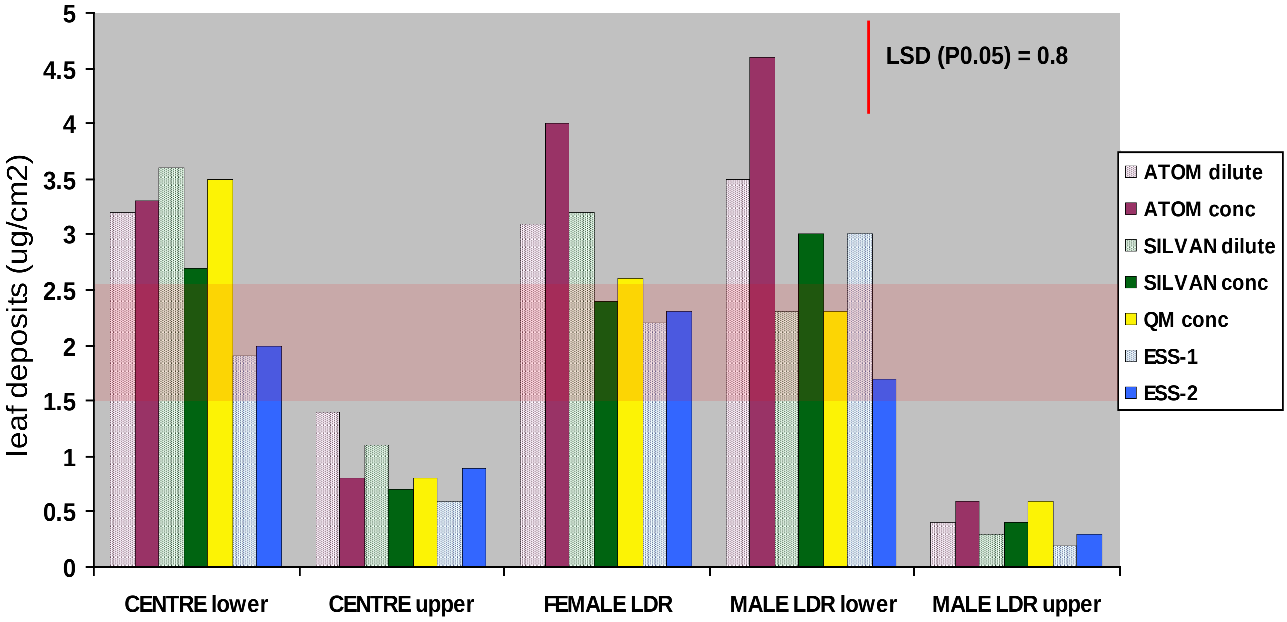


Fig. 7: Mean deposits (µg/cm²) on all zones of Hayward canopy (Study 1) from a normalised application of 1 kg/ha dye in each treatment

QM Dilute treatment data is unavailable in this study
due to an application error in the field trial.

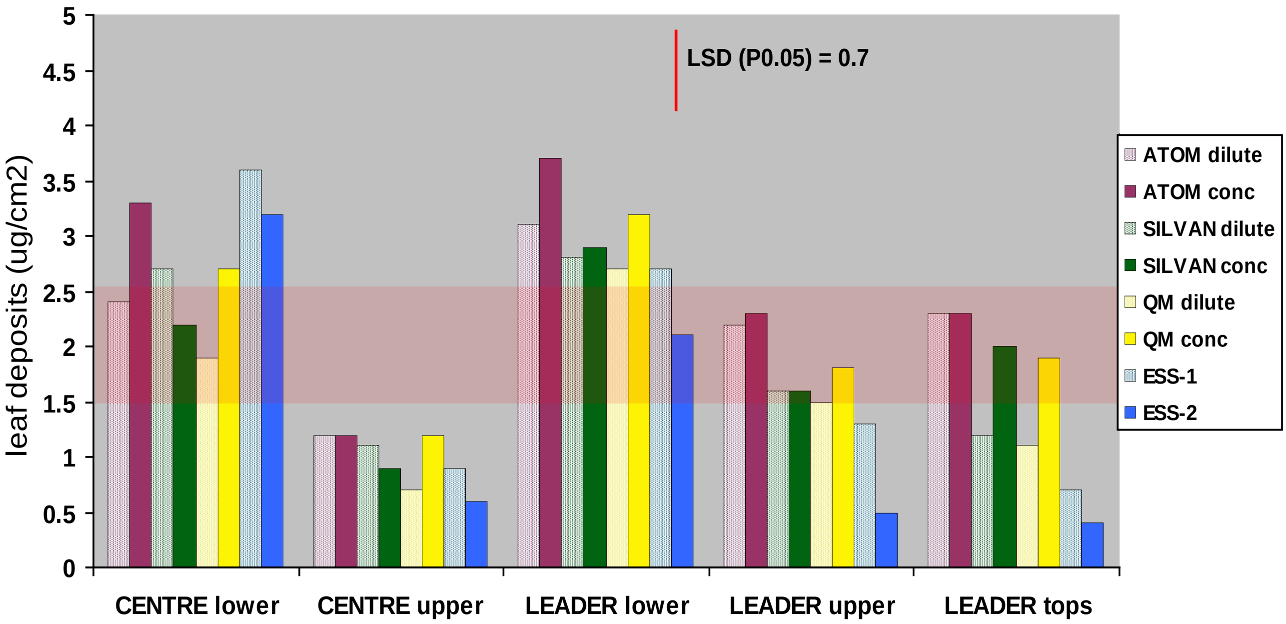


Fig. 8: Mean deposits (µg/cm²) on all zones of Hort 16A canopy (Study 2) from a normalised application of 1 kg/ha dye in each treatment

WSP studies

Spray deposit assessments using wash-off recovery of a tracer from bulked leaf samples cannot provide any data on surface-to-surface variations in spray deposits. Experience in large-leafed crops like kiwifruit has shown that there can be large variations in deposits between leaf surfaces (Gaskin *et al.* 2011). WSPs provide a very useful indication of spray droplet sizes and where spray droplets deposit, but it is impossible to assess spray deposit levels accurately from WSPs. However, they provide an important view on surface-to-surface coverage variability that the quantitative deposit assessments do not.

The WSPs for Studies 1 & 2 are included in Appendices 4&5. In Study 1, the WSPs reflected the measured deposits within treatments well in the lower canopy, at both centre row and leader positions, but poorly in both the upper canopy zones. In the leader zone this is likely due to the extreme density of the un-pruned male vines, but the reason for the poor correlation in the upper centre zone is unknown. In Study 2, WSPs generally reflected measured deposits within treatments well throughout. When comparing WSPs for dilute (1000 L/ha) versus concentrate (500 L/ha) treatments, it should be taken into account that chemical dose in the concentrate deposits is twice that in dilute. Although not seen on the WSPs, the concentrate spray droplets will also spread twice as much as the dilute spray droplets on leaf surfaces because of the increased concentration of Du-Wett in the concentrate sprays (refer Table 2 and Gaskin *et al.* 2011b).

In the case of the ESS sprayer, WSP do not show the spray deposits well because of the low spray volume applied and very small droplet size. However, chemical dose in the ESS visible deposits will be approx. 6x more concentrated than in dilute (1000 L/ha) sprays and 3x more concentrated than in concentrate (500 L/ha) sprays.

In this study, the number of leaf surfaces monitored by quantitative deposits was 5x that monitored by WSPs and the area sampled for quantitative deposits was ca 400x greater than sampled on WSP. Thus, deposits will provide a much more accurate measure than WSPs, but WSPs provide some useful information about deposits reaching the upper versus lower surfaces of leaves within the canopy zones. An examination of the WSPs indicated that the ESS potentially distributed spray most evenly on both leaf surfaces. This effect is likely due to the small size of and electrical charge on the spray droplets the ESS produces. However, it should be noted that all sprayers failed to achieve acceptable penetration and deposits in dense canopy zones.

CONCLUSIONS

The sprayers

- No sprayer showed a markedly superior performance to the others.

- Deposits and deposit variability from the Atom, Silvan and Quantum Mist sprayers were comparable.

- The Atom sprayer tended to achieve the highest average deposits.

- Deposits from the Electrostatic sprayer tended to be lower than those from the other sprayers and showed the greatest deposit variability on canopy zones.

Canopy effects on deposits

- The variation in deposits was greater between canopy zones than between sprayers, indicating that the canopy is the primary factor affecting deposit levels.

- This implies that canopy management is likely to be of greater importance in Psa control than the type of sprayer used.

- Deposits in dense upper male canopy zones were significantly lower across all of the sprayers and spray volumes tested. Dense canopy zones are difficult to treat with any sprayer.

- All sprayers tested in this study are likely to provide satisfactory spray coverage on canopies that are managed to minimise density, but the effects of varying canopy density must be quantified to factor into guidelines for sprayer setup.

Dilute versus concentrate sprays

- Deposits from both dilute and 2x concentrate application volumes were comparable.

- These tests have indicated that higher deposits can be achieved from concentrate sprays in regular open canopies.

- Canopy management may allow even more concentrated sprays to be used for greater spraying efficiency.

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APPENDIX 1
Canopy characterisation

Leaf layer numbers were counted and canopy depth was measured from the row centre and leader zones of each treatment sample plot (5 replicate measurements taken for each zone per treatment). Average leaf layer numbers in this case provide a direct estimate of canopy leaf area index (LAI = hectares of projected leaf area per canopy hectare). The sampling undertaken provided a useful relative measure of canopy density differences between sprayed plots and between the two different orchards.

Study 1, Rep 1: Hayward canopy

Tmt	Sprayer	Number of leaf layers			Mean depth of canopy (cm)		
		Centre row	Female LDR	Male LDR	Centre row	Female LDR	Male LDR
1	Atom dilute	3.4	3.0	9.4	31	49	99
2	Atom conc.	3.8	3.2	8.8	36	55	101
3	Silvan dilute	4.8	3.0	7.4	47	58	84
4	Silvan conc.	3.6	2.4	8.4	31	n	97
5	QM dilute	3.0	2.4	8.8	30	n	101
6	QM conc.	4.0	3.2	8.0	37	53	107
7	ESS-1	3.6	1.5	8.2	30	n	94
8	ESS-2	3.0	3.0	8.4	33	56	102
	Overall mean	*3.7*	*2.7*	*8.4*	*34*	*54*	*98*

All data is mean of 5 random measurements in each canopy zone of sample plot
n = not measured because pruned canopy so sparse

Study 1, Rep 2: Hayward canopy

Tmt	Sprayer	Number of leaf layers			Mean depth of canopy (cm)		
		Centre row	Female LDR	Male LDR	Centre row	Female LDR	Male LDR
1	Atom dilute	2.8	3.0	7.0	39	58	72
2	Atom conc.	2.8	2.5	5.4	35	n	72
3	Silvan dilute	2.4	3.4	5.8	33	64	76
4	Silvan conc.	3.8	4.2	5.2	42	54	70
5	QM dilute	2.8	1.6	6.8	30	n	88
6	QM conc.	2.4	3.6	6.0	30	59	79
7	ESS-1	2.4	1.5	5.8	32	n	95
8	ESS-2	2.6	4.2	5.8	33	55	72
	Overall mean	*2.8*	*3.0*	*6.0*	*34*	*58*	*78*

All data is mean of 5 random measurements in each canopy zone of sample plot
n = not measured because pruned canopy so sparse

APPENDIX 1 (continued)

Study 2, Rep 1: Hort 16A canopy

Tmt	Sprayer	Number of leaf layers		Mean depth of canopy (cm)		
		Centre row	Female LDR	Centre row	LDR	Maximum at LDR (new growth)
1	Atom dilute	3.6	3.0	32	50	96
2	Atom conc.	3.2	3.0	27	40	114
3	Silvan dilute	4.0	2.6	35	41	110
4	Silvan conc.	4.8	3.4	36	42	146
5	QM dilute	4.0	3.2	34	46	144
6	QM conc.	3.8	3.6	32	42	118
7	ESS-1	4.0	2.8	35	37	114
8	ESS-2	4.2	3.8	42	50	114
	Overall mean	*4.0*	*3.2*	*34*	*44*	*120*

All data is mean of 5 random measurements in each canopy zone of sample plot
n = not measured because pruned canopy so sparse

Study 2, Rep 2: Hort 16A canopy

Tmt	Sprayer	Number of leaf layers		Mean depth of canopy (cm)		
		Centre row	Female LDR	Centre row	LDR	Maximum at LDR (new growth)
1	Atom dilute	4.0	3.4	41	38	179
2	Atom conc.	3.8	2.8	38	40	147
3	Silvan dilute	3.8	3.8	39	41	106
4	Silvan conc.	4.6	3.2	51	44	109
5	QM dilute	2.8	3.6	32	39	185
6	QM conc.	2.8	2.6	26	34	123
7	ESS-1	2.6	2.8	28	47	105
8	ESS-2	4.2	3.0	36	40	106
	Overall mean	*3.6*	*3.2*	*36*	*40*	*133*

All data is mean of 5 random measurements in each canopy zone of sample plot
n = not measured because pruned canopy so sparse

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APPENDIX 2
Sprayer setup and nozzling details

Atom airblast sprayer

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
8/12/2011	Sprayer comparison 1 Huse Lane TePuke - Green pergola with dense males 5 m row spacing	Atom 2000 turbo Evo Modena. Arivac front entry 920mm diameter fan Eight possible nozzle positions per side - two nozzle rings available	1000	12X nozzles used per side (6 on both front and rear rings) 4X Albuz ATR ceramic hollow cones + 2X D Series ceramic disk and core	6.0	42000
			500	6X nozzles used per side on front ring only 4X Albuz ATR ceramic hollow cones + 2X D Series ceramic disk and core	6.0	42000

Setup Details — Atom 500 l/ha 5.0 m pergola, Albuz ATR & TeeJet D Series ceramic cone nozzles

NOZZLING DETAILS

Nozzle pressure 1520 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Front nozzle ring	1	Yellow	1.31	10.5%	10%	Med-Wide
	2	Orange	1.73	13.9%	24%	Med-Wide
	3	Orange	1.73	13.9%	38%	Med-Wide
	4	Red	2.46	19.6%	58%	Med-Wide
	5	D3-35	2.45	19.6%	77%	Narrow
	6	D3-46	2.82	22.6%	100%	Narrow
	7	Off				
	8	Off				
Rear nozzle ring	1	Off				
	2	Off				
	3	Off				
	4	Off				
	5	Off				
	6	Off				
	7	Off				
	8	Off				
		Output from one side (l/min)	12.5			
		Total output (l/min)	25.0			

Setup Details — Atom 1000 l/ha 5.0 m pergola, Albuz ATR & TeeJet D Series ceramic cone nozzles

NOZZLING DETAILS

Nozzle pressure 1520 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Front nozzle ring	1	Yellow	1.31	5.2%	5%	Med-Wide
	2	Orange	1.73	6.9%	12%	Med-Wide
	3	Orange	1.73	6.9%	19%	Med-Wide
	4	Red	2.46	9.8%	29%	Med-Wide
	5	D3-35	2.45	9.8%	39%	Narrow
	6	D3-46	2.82	11.3%	50%	Narrow
	7	Off				
	8	Off				
Rear nozzle ring	1	Yellow	1.31	5.2%	5%	Med-Wide
	2	Orange	1.73	6.9%	12%	Med-Wide
	3	Orange	1.73	6.9%	19%	Med-Wide
	4	Red	2.46	9.8%	29%	Med-Wide
	5	D3-35	2.45	9.8%	39%	Narrow
	6	D3-46	2.82	11.3%	50%	Narrow
	7	Off				
	8	Off				
		Output from one side (l/min)	25.0			
		Total output (l/min)	50.0			

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
9/12/2011	Sprayer comparison 2 TeMatai Rd TePuke - Gold pergola 4.4 m rows	Atom 2000 turbo Evo Modena. Arivac front entry 920mm diameter fan Eight possible nozzle positions per side - two nozzle rings available	1000	Five nozzles used per side on front and rear rings 4X Albuz ATR ceramic hollow cones + 1x D Series ceramic disk and core	6.0	37000
			500	Five nozzles used per side on front ring only 4X Albuz ATR ceramic hollow cones + 1x D Series ceramic disk and core	6.0	37000

Setup Details — Atom 500 l/ha 4.4 m pergola, Albuz ATR & TeeJet D Series ceramic cone nozzles

NOZZLING DETAILS

Nozzle pressure 2080 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Front nozzle ring	1	Yellow	1.52	13.5%	14%	Med-Wide
	2	Orange	2.02	17.9%	31%	Med-Wide
	3	Orange	2.02	17.9%	49%	Med-Wide
	4	Red	2.86	25.4%	75%	Med-Wide
	5	D3-35	2.83	25.2%	100%	Narrow
	6	Off				
	7	Off				
	8	Off				
Rear nozzle ring	1	Off				
	2	Off				
	3	Off				
	4	Off				
	5	Off				
	6	Off				
	7	Off				
	8	Off				
		Output from one side (l/min)	11.2			
		Total output (l/min)	22.5			

Setup Details — Atom 1000 l/ha 4.4 m pergola, Albuz ATR & TeeJet D Series ceramic cone nozzles

NOZZLING DETAILS

Nozzle pressure 2080 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Front nozzle ring	1	Yellow	1.52	6.8%	7%	Med-Wide
	2	Orange	2.02	9.0%	16%	Med-Wide
	3	Orange	2.02	9.0%	25%	Med-Wide
	4	Red	2.86	12.7%	37%	Med-Wide
	5	D3-35	2.83	12.6%	50%	Narrow
	6	Off				
	7	Off				
	8	Off				
Rear nozzle ring	1	Yellow	1.52	6.8%	7%	Med-Wide
	2	Orange	2.02	9.0%	16%	Med-Wide
	3	Orange	2.02	9.0%	25%	Med-Wide
	4	Red	2.86	12.7%	37%	Med-Wide
	5	D3-35	2.83	12.6%	50%	Narrow
	6	Off				
	7	Off				
	8	Off				
		Output from one side (l/min)	22.5			
		Total output (l/min)	45.0			

Plant Protection Chemistry NEW ZEALAND

APPENDIX 2 (continued)

Silvan Kiwifruit sprayer

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
8/12/2011	Sprayer comparison 1 Huse Lane TePuke - Green pergola with dense males	Silvan kiwifruit sprayer - With four split air ducts per side. Duct air outlet angles fixed in direction of travel at ca. 15° forward and 15° back angled.	1000	8X Arag HCI 80 ceramic hollow cones per side (ATR equivalent) 2X nozzles/head (one each in leading + trailing air streams)	6.0	8000
	5 m row spacing	Duct spacing and angles across row adjusted	500	8X Arag HCI 80 ceramic hollow cones per side (ATR equivalent) 2X nozzles/head (one each in leading + trailing air streams)	6.0	8000

Silvan Kiwi 500 l/ha 5.0 m pergola
Arag International Spray Jet fine droplet hollow cone ceramic nozzles

Setup Details

NOZZLING DETAILS

Nozzle pressure 1720 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head 1	1	Red	2.61	20.9%	21%	Med-Wide
	2	Red	2.61	20.9%	42%	Med-Wide
Head 2	3	Orange	1.84	14.7%	56%	Med-Wide
	4	Orange	1.84	14.7%	71%	Med-Wide
Head 3	5	Brown	0.90	7.2%	78%	Med-Wide
	6	Brown	0.90	7.2%	86%	Med-Wide
Inner head 4	7	Brown	0.90	7.2%	93%	Med-Wide
	8	Brown	0.90	7.2%	100%	Med-Wide
		Output from one side (l/min)	12.5			
		Total output (l/min)	25.0			

Silvan Kiwi 1000 l/ha 5.0 m pergola
Arag International Spray Jet fine droplet hollow cone ceramic nozzles

Setup Details

NOZZLING DETAILS

Nozzle pressure 1740 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head 1	1	Blue	4.62	18.5%	18%	Med-Wide
	2	Blue	4.62	18.5%	37%	Med-Wide
Head 2	3	Green	3.34	13.4%	50%	Med-Wide
	4	Green	3.34	13.4%	64%	Med-Wide
Head 3	5	Grey	2.70	10.8%	74%	Med-Wide
	6	Grey	2.70	10.8%	85%	Med-Wide
Inner head 4	7	Orange	1.85	7.4%	93%	Med-Wide
	8	Orange	1.85	7.4%	100%	Med-Wide
		Output from one side (l/min)	25.0			
		Total output (l/min)	50.0			

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
9/12/2011	Sprayer comparison 2 TeMatai Rd TePuke - Gold pergola	Silvan kiwifruit sprayer - With four split air ducts per side. Duct air outlet angles fixed in direction of travel at ca. 15° forward and 15° back	1000	8X Arag HCI 80 ceramic hollow cones per side (ATR equivalent) 2X nozzles/head (one each in leading + trailing air streams)	6.0	8000
	4.4 m rows	angled. Duct spacing and angles across row adjusted to give even coverage of canopy.	500	8X Arag HCI 80 ceramic hollow cones per side (ATR equivalent) 2X nozzles/head (one each in leading + trailing air streams)	6.0	8000

Silvan Kiwi 500 l/ha 4.4 m pergola
Arag International Spray Jet fine droplet hollow cone ceramic nozzles

Setup Details

NOZZLING DETAILS

Nozzle pressure 2170 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head 1	1	Orange	2.06	18.3%	18%	Med-Wide
	2	Orange	2.06	18.3%	37%	Med-Wide
Head 2	3	Yellow	1.55	13.8%	50%	Med-Wide
	4	Yellow	1.55	13.8%	64%	Med-Wide
Head 3	5	Brown	1.01	9.0%	73%	Med-Wide
	6	Brown	1.01	9.0%	82%	Med-Wide
Inner head 4	7	Brown	1.01	9.0%	91%	Med-Wide
	8	Brown	1.01	9.0%	100%	Med-Wide
		Output from one side (l/min)	11.3			
		Total output (l/min)	22.5			

Silvan Kiwi 1000 l/ha 4.4 m pergola
Arag International Spray Jet fine droplet hollow cone ceramic nozzles

Setup Details

NOZZLING DETAILS

Nozzle pressure 1980 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head 1	1	Green	3.56	15.8%	16%	Med-Wide
	2	Green	3.56	15.8%	32%	Med-Wide
Head 2	3	Grey	2.86	12.7%	44%	Med-Wide
	4	Grey	2.86	12.7%	57%	Med-Wide
Head 3	5	Grey	2.86	12.7%	70%	Med-Wide
	6	Grey	2.86	12.7%	83%	Med-Wide
Inner head 4	7	Orange	1.97	8.7%	91%	Med-Wide
	8	Orange	1.97	8.7%	100%	Med-Wide
		Output from one side (l/min)	22.5			
		Total output (l/min)	45.0			

Plant Protection Chemistry NEW ZEALAND

APPENDIX 2 (continued)

Croplands Kiwi Quantum sprayer

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
8/12/2011	Sprayer comparison 1 Huse Lane TePuke - Green pergola with dense males 5 m row spacing	Quantum Mist - 3X QM500 heads per side. Heads staggered and angled to deliver full overlap of air and spray output across row. Fan speed ca. 2300 rpm.	1000	18X Albuz ATR ceramic hollow cone nozzles (6 per head)	5.8	84000
			500	18X Albuz ATR ceramic hollow cone nozzles (6 per head)	5.9	84000

Setup Details — Kiwi Quantum 500 l/ha 5.0 m pergola
Albuz ATR fine droplet hollow cone ceramic nozzles

NOZZLING DETAILS

Nozzle pressure 790 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head	1	Lilac	0.48	3.9%	4%	Med-Wide
	2	Lilac	0.48	3.9%	8%	Med-Wide
	3	Brown	0.62	5.0%	13%	Med-Wide
	4	Brown	0.62	5.0%	18%	Med-Wide
	5	Brown	0.62	5.0%	23%	Med-Wide
	6	Brown	0.62	5.0%	28%	Med-Wide
	7	Brown	0.62	5.0%	33%	Med-Wide
	8	Brown	0.62	5.0%	38%	Med-Wide
Mid head	9	Lilac	0.48	3.9%	42%	Med-Wide
	10	Lilac	0.48	3.9%	46%	Med-Wide
	11	Lilac	0.48	3.9%	50%	Med-Wide
	12	Lilac	0.48	3.9%	53%	Med-Wide
	13	Lilac	0.48	3.9%	57%	Med-Wide
	14	Lilac	0.48	3.9%	61%	Med-Wide
	15	Lilac	0.48	3.9%	65%	Med-Wide
	16	Lilac	0.48	3.9%	69%	Med-Wide
Inner head	17	Lilac	0.48	3.9%	73%	Med-Wide
	18	Lilac	0.48	3.9%	77%	Med-Wide
	19	Lilac	0.48	3.9%	81%	Med-Wide
	20	Lilac	0.48	3.9%	84%	Med-Wide
	21	Lilac	0.48	3.9%	88%	Med-Wide
	22	Lilac	0.48	3.9%	92%	Med-Wide
	23	Lilac	0.48	3.9%	96%	Med-Wide
	24	Lilac	0.48	3.9%	100%	Med-Wide
Output from one side (l/min)			12.3			
Total output (l/min)			24.6			

Setup Details — Kiwi Quantum 1000 l/ha 5.0 m pergola
Albuz ATR fine droplet hollow cone ceramic nozzles

NOZZLING DETAILS

Nozzle pressure 845 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head	1	Brown	0.64	2.6%	3%	Med-Wide
	2	Yellow	0.98	4.1%	7%	Med-Wide
	3	Yellow	0.98	4.1%	11%	Med-Wide
	4	Yellow	0.98	4.1%	15%	Med-Wide
	5	Yellow	0.98	4.1%	19%	Med-Wide
	6	Orange	1.30	5.4%	24%	Med-Wide
	7	Orange	1.30	5.4%	30%	Med-Wide
	8	Orange	1.30	5.4%	35%	Med-Wide
Mid head	9	Brown	0.64	2.6%	38%	Med-Wide
	10	Brown	0.64	2.6%	40%	Med-Wide
	11	Yellow	0.98	4.1%	45%	Med-Wide
	12	Yellow	0.98	4.1%	49%	Med-Wide
	13	Yellow	0.98	4.1%	53%	Med-Wide
	14	Yellow	0.98	4.1%	57%	Med-Wide
	15	Orange	1.30	5.4%	62%	Med-Wide
	16	Orange	1.30	5.4%	68%	Med-Wide
Inner head	17	Brown	0.64	2.6%	70%	Med-Wide
	18	Brown	0.64	2.6%	73%	Med-Wide
	19	Yellow	0.98	4.1%	77%	Med-Wide
	20	Yellow	0.98	4.1%	81%	Med-Wide
	21	Yellow	0.98	4.1%	85%	Med-Wide
	22	Yellow	0.98	4.1%	89%	Med-Wide
	23	Orange	1.30	5.4%	95%	Med-Wide
	24	Orange	1.30	5.4%	100%	Med-Wide
Output from one side (l/min)			24.1			
Total output (l/min)			48.3			

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APPENDIX 2 (continued)

Croplands Kiwi Quantum sprayer

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
9/12/2011	Sprayer comparison 2 TeMatai Rd TePuke - Gold pergola 4.4 m rows	Quantum Mist - 3X QM500 heads per side. Heads staggered and angled to deliver full overlap of air and spray output across row. Fan speed ca. 2300 rpm.	1000	18X Albuz ATR ceramic hollow cone nozzles per side	6.0	84000
			500	18X Albuz ATR ceramic hollow cone nozzles per side	6.0	84000

Setup Details — Kiwi Quantum 500 l/ha 4.4 m pergola
Albuz ATR fine droplet hollow cone ceramic nozzles

NOZZLING DETAILS

Nozzle pressure 660 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head	1	Lilac	0.44	3.9%	4%	Med-Wide
	2	Lilac	0.44	3.9%	8%	Med-Wide
	3	Brown	0.57	5.0%	13%	Med-Wide
	4	Brown	0.57	5.0%	18%	Med-Wide
	5	Brown	0.57	5.0%	23%	Med-Wide
	6	Brown	0.57	5.0%	28%	Med-Wide
	7	Brown	0.57	5.0%	33%	Med-Wide
	8	Brown	0.57	5.0%	38%	Med-Wide
Mid head	9	Lilac	0.44	3.9%	42%	Med-Wide
	10	Lilac	0.44	3.9%	46%	Med-Wide
	11	Lilac	0.44	3.9%	50%	Med-Wide
	12	Lilac	0.44	3.9%	53%	Med-Wide
	13	Lilac	0.44	3.9%	57%	Med-Wide
	14	Lilac	0.44	3.9%	61%	Med-Wide
	15	Lilac	0.44	3.9%	65%	Med-Wide
	16	Lilac	0.44	3.9%	69%	Med-Wide
Inner head	17	Lilac	0.44	3.9%	73%	Med-Wide
	18	Lilac	0.44	3.9%	77%	Med-Wide
	19	Lilac	0.44	3.9%	81%	Med-Wide
	20	Lilac	0.44	3.9%	84%	Med-Wide
	21	Lilac	0.44	3.9%	88%	Med-Wide
	22	Lilac	0.44	3.9%	92%	Med-Wide
	23	Lilac	0.44	3.9%	96%	Med-Wide
	24	Lilac	0.44	3.9%	100%	Med-Wide
		Output from one side (l/min)	11.3			
		Total output (l/min)	22.5			

Setup Details — Kiwi Quantum 1000 l/ha 4.4 m pergola
Albuz ATR fine droplet hollow cone ceramic nozzles

NOZZLING DETAILS

Nozzle pressure 730 kPa (aprox)

Description		Nozzle name	Predicted output	%	Cum%	Nozzle angle
Outer head	1	Brown	0.59	2.6%	3%	Med-Wide
	2	Yellow	0.92	4.1%	7%	Med-Wide
	3	Yellow	0.92	4.1%	11%	Med-Wide
	4	Yellow	0.92	4.1%	15%	Med-Wide
	5	Yellow	0.92	4.1%	19%	Med-Wide
	6	Orange	1.21	5.4%	24%	Med-Wide
	7	Orange	1.21	5.4%	30%	Med-Wide
	8	Orange	1.21	5.4%	35%	Med-Wide
Mid head	9	Brown	0.59	2.6%	38%	Med-Wide
	10	Brown	0.59	2.6%	40%	Med-Wide
	11	Yellow	0.92	4.1%	45%	Med-Wide
	12	Yellow	0.92	4.1%	49%	Med-Wide
	13	Yellow	0.92	4.1%	53%	Med-Wide
	14	Yellow	0.92	4.1%	57%	Med-Wide
	15	Orange	1.21	5.4%	62%	Med-Wide
	16	Orange	1.21	5.4%	68%	Med-Wide
Inner head	17	Brown	0.59	2.6%	70%	Med-Wide
	18	Brown	0.59	2.6%	73%	Med-Wide
	19	Yellow	0.92	4.1%	77%	Med-Wide
	20	Yellow	0.92	4.1%	81%	Med-Wide
	21	Yellow	0.92	4.1%	85%	Med-Wide
	22	Yellow	0.92	4.1%	89%	Med-Wide
	23	Orange	1.21	5.4%	95%	Med-Wide
	24	Orange	1.21	5.4%	100%	Med-Wide
		Output from one side (l/min)	22.5			
		Total output (l/min)	45.0			

APPENDIX 2 (continued)

ESS Electrostatic sprayer

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
8/12/2011	Sprayer comparison 1 Huse Lane TePuke - Green pergola with dense males 5 m row spacing	ESS Electrostatic - nozzles ca. 0.6m below canopy. Heads forward angled ca. 15° and back angled ca. 30° Heads angled across row to give full cover.	200	18x ESS nozzles per side each delivering 0.23 l/min Treatments applied to half row sections in each sprayer pass	5.0	210
			238	18x ESS nozzles per side each delivering 0.23 l/min Treatments applied to half row sections in each sprayer pass	4.2	210

Date	Trial site/name	Sprayer	Application volume (l/ha)	Nozzles (per side)	Speed (km/hr)	Air output (aprox m^3/hr)
9/12/2011	Sprayer comparison 2 TeMatai Rd TePuke - Gold pergola 4.4 m rows	ESS Electrostatic - nozzles ca. 0.8m below canopy. Heads forward angled ca. 15° and back angled ca. 30° Heads angled across row to give full cover.	150	14X ESS nozzles per side each delivering ca. 0.2 l/min Treatments applied as a full row sprayer	5.0	210
			120	14X ESS nozzles per side each delivering ca. 0.2 l/min Treatments applied as a full row sprayer	6.2	210

APPENDIX 2 (continued)

Sprayer technology discussion and recommendations

A brief summary of issues and questions identified around the different spraying technologies tested follows.

Atom air blast sprayer:

Sprayer air assistance

- Observation of the spray plume in the first (5 m row green canopy) suggested that the sprayer was producing too much air output and this was dropped in the second canopy (4.4 m row gold).
- How best to **identify** optimal air outputs for different canopies and how can operators best **achieve** these? At present there are no easy to follow guidelines for quantifying and optimising airblast sprayer air outputs for different canopies, wind conditions and travel speeds. This is an area of research and extension that has been flagged for further development.
- It was considered that this type of sprayer might benefit from the addition of adjustable guns on the lower nozzle positions, to allow a narrow pattern of spray to be directed into dense leaders.
- The sprayer tested featured a front entry fan. The relative performance of front entry fans against rear entry fans has been tested in other experiments conducted in 2011-12. There may be potential for front entry fans to achieve greater rear angling of outputs and greater spray plume width - both of which may improve overall deposits.

Spray output distribution

- The spray nozzling and output distributions used these tests were based on current industry standard nozzlings and recommendations. The deposit distributions measured as a result of these tests indicated that more spray volume needs to be directed to the densest canopy areas (upper leader zone in the 5 m row green block and upper row centres in the 4.4 m row gold block). However, this type of adjustment would require a level of sophistication in identifying and responding to variations in canopy density that is unlikely to ever be practical unless the sprayer could somehow directly sense and respond to canopy density (this type of technology exists but is expensive and has not been applied to kiwifruit or similar canopies).
- The influence of canopy density on spray deposit levels was the key result of this work, with all sprayers failing to achieve acceptable deposit levels in very dense canopy. This result, coupled with our current inability to rapidly adjust spray output distributions in response to varying canopy densities within blocks, suggests that further work is needed to manage canopies to achieve even and open densities – with sprayer setup and output distributions well matched to these.

The novel sprayers.

Sprayer configuration

- All of the novel sprayers compared with the Atom airblast in these tests featured a variation on an extended boom configuration. The orchard blocks used in the deposit studies were all flat, with even row spacings. Many orchard blocks within the NZ industry feature some rows with non-standard row spacings (eg where shelter has been removed), tight headlands and sloping topography. In all three novel sprayers tested the researchers identified a need to ensure that the sprayer was capable of easy adjustment to maintain deposits and coverage between blocks on different row spacings and to accommodate some of the within-block variations found in the industry.
- All three sprayers were found to achieve deposits and gross deposit distributions similar to those achieved with the Atom airblast sprayer, with canopy density the overriding factor determining deposit levels.

Sprayer air assistance general

- The air output volumes were estimated from all four sprayers used in these tests by multiplying measured air output speeds at the nozzles by the cross sectional area of the air outlet. This method of air output assessment has proven useful to compare the relative performance potential of different axial fan airblast sprayers. However, it did not appear to provide a useful basis for comparing the potential canopy penetration and spray deposits from the different sprayers. Measured in the way described, there were enormous differences in air output volumes from the different sprayers (Appendix 3) that in no way reflected their actual deposit performance. A better method for measuring and comparing air assistance from different types of sprayers is required.

Silvan kiwifruit sprayer:

- The unit tested did not allow adjustment of air output orientation (relative to direction of travel) or to the angles between the ducts. It is possible that the performance of this sprayer could be further improved by widening the output angles between the fore and aft angled air outlets (as seen with the ESS sprayer on water sensitive papers) and/or by altering the initial angle of output of the lead part of the head (possibly make this more vertical rather than forward angled).

Croplands Kiwi Quantum:

- The unit tested was a half row plot sprayer with 3 x 500 mm diameter heads per side. The Quantum Mist heads generate a large amount of air and it is possible that using a full row machine would have changed the spray penetration potential in the mid row zone.

ESS electrostatic:

- The unit tested was a first test prototype and was excellent for this purpose. The nozzles were operated with equal output volumes delivered from each, with head angling used to achieve the required output distribution across the canopy row. Future development with this type of machine may need to consider options to place more nozzles to target particular canopy zones and/or differential outputs from the different nozzles.
- This type of sprayer is limited to low volume applications in order to maintain the small droplet sizes required for the electrostatic deposit effect to work. Further work would be required to determine application volumes and chemical application rates for practical, safe and effective low volume spraying of mineral oils and many other chemicals used in kiwifruit.

APPENDIX 3

All wind speeds were recorded immediately above the canopy adjacent to sprayed rows.

Summary of wind speeds (m/sec) for Study 1 (8/12/11)

Tmt	Sprayer	Start time	Rep 1		Rep 2	
			Mean wind speed	Max wind speed	Mean wind speed	Max wind speed
1	Atom dilute	1010	0.1	0.3	0	0.05
2	Atom conc.	1040	0.2	0.7	0	0
3	Silvan dilute	1120	0	0	0.2	0.8
4	Silvan conc.	1155	0.6	1.5	0.1	0.3
5	QM dilute	1340	0.2	0.9	0.1	0.9
6	QM conc.	1430	0.7	2.3	0.7	0.9
7	ESS-1	1550	0.5	1.2	0.2	0.7
8	ESS-2	1630	0.1	0.2	0.4	1.3

Temperature was between 22-26°C for all treatments

Summary of wind speeds (m/sec) for Study 2 (9/12/11)

Tmt	Sprayer	Start time	Rep 1		Rep 2	
			Mean wind speed	Max wind speed	Mean wind speed	Max wind speed
1	Atom dilute	1145	0.5	1.1	0.6	1.0
2	Atom conc.	1210	0.9	2.6	0.4	0.8
3	Silvan dilute	1110	0.3	0.8	0.1	0.6
4	Silvan conc.	1400	0.5	1.7	0.2	1.0
5	QM dilute	1310	1.4	2.5	1.0	2.9
6	QM conc.	1510	0.4	1.0	0.3	1.2
7	ESS-1	1240	0.8	1.4	0.1	0.7
8	ESS-2	1435	1.0	1.8	0.4	0.9

Temperature was between 21-26°C for all treatments

APPENDIX 4

Water sensitive paper record of sprayers assessed in Study #1

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

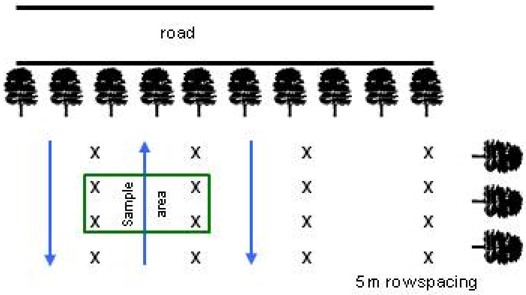
Date: 8th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.08 m/s (0.25 max)
Temperature: 22°

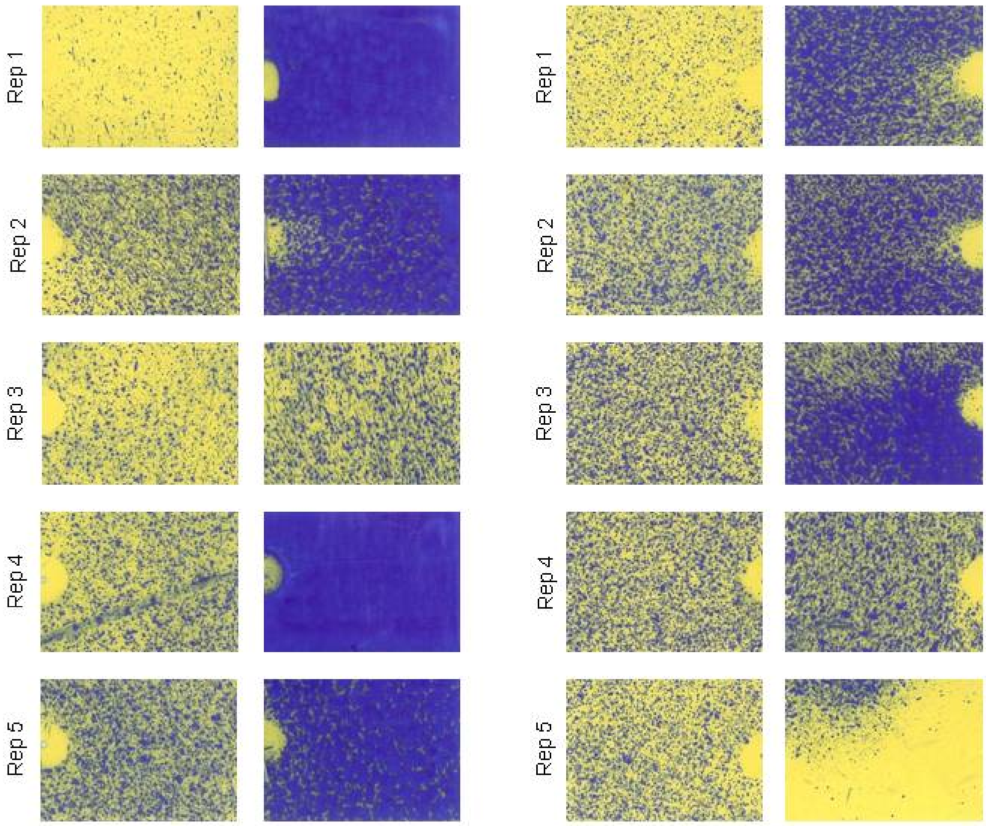
Nozzles: 4x Albuz ATR ceramic hollow cone & 2x D series ceramic disk & core. (per side). Twin rings operating
Pressure: 1430 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:



Trt: Atom_dilute_400ml/ha Du-wett (0.04%)

Centre lower canopy deposits		**Centre upper canopy deposits**	
Upper surface	Lower surface	Upper surface	Lower surface



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Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

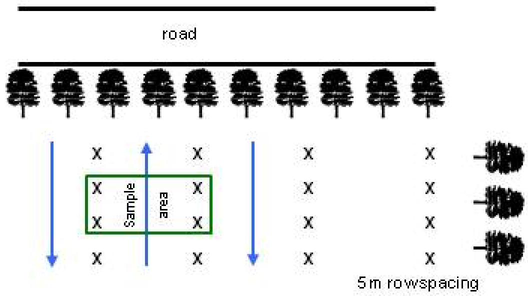
Date: 8th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.08 m/s (0.25 max)
Temperature: 22°

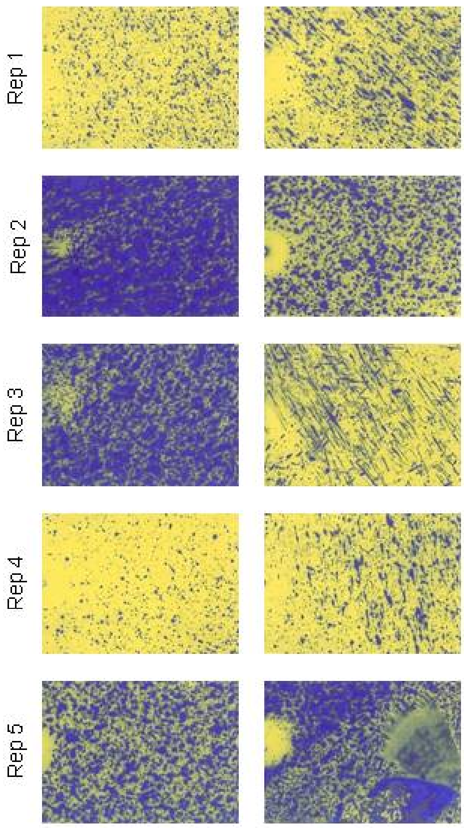
Nozzles: 4x Albuz ATR ceramic hollow cone & 2x D series ceramic disk & core. (per side). Twin rings operating
Pressure: 1430 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

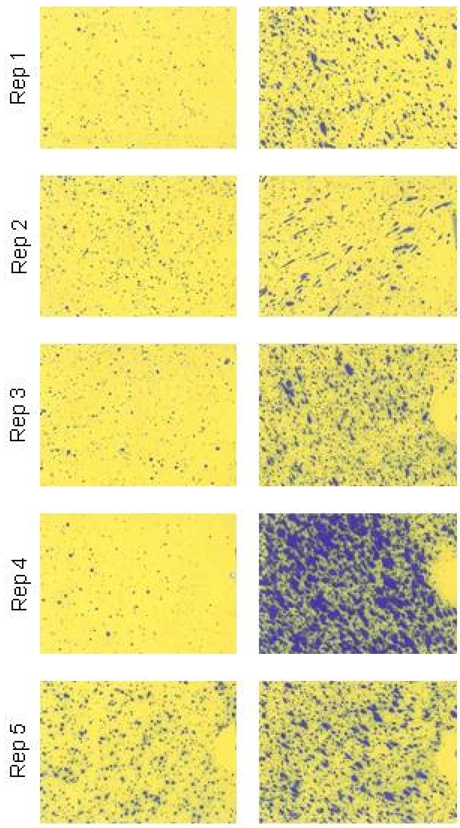


Trt: Atom_dilute_400ml/ha Du-wett (0.04%)

Male leader lower canopy deposits
Upper surface   Lower surface



Male leader upper canopy deposits
Upper surface   Lower surface



Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

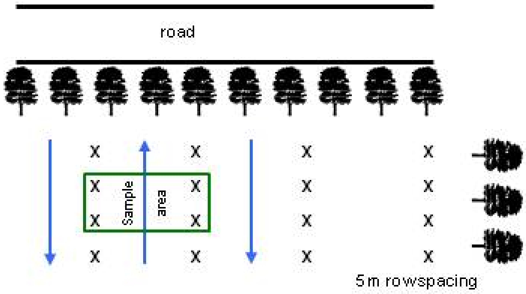
Date: 8th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.21 m/s (0.73 max)
Temperature: 22°

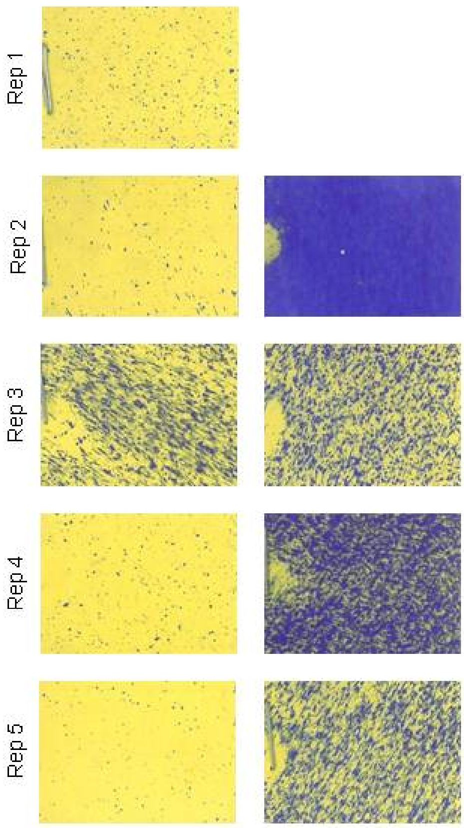
Nozzles: 4x Albuz ATR ceramic hollow cone & 2x D series ceramic disk & core. (per side). Front ring only.
Pressure: 1450 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

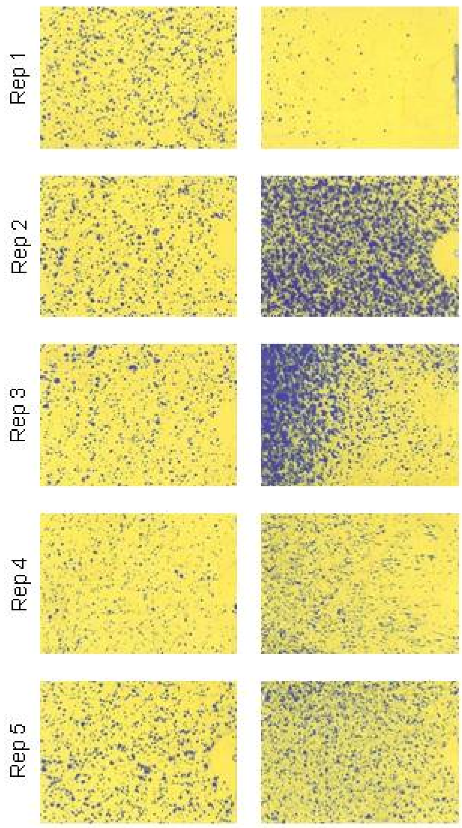


Trt: Atom_concentrate_400ml/ha Du-wett (0.08%)

Centre lower canopy deposits
Upper surface   Lower surface



Centre upper canopy deposits
Upper surface   Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

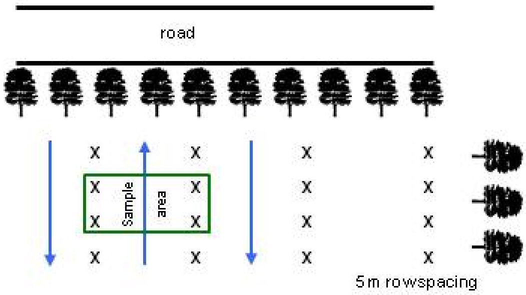
Date: 8th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.21 m/s (0.73 max)
Temperature: 22°

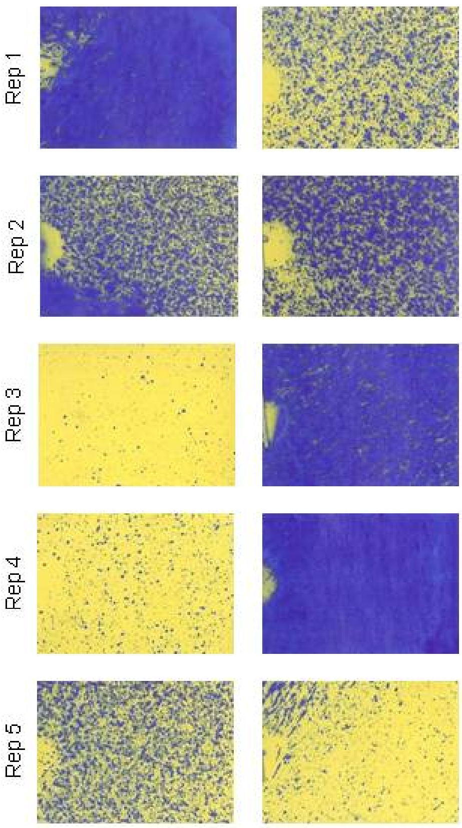
Nozzles: 4x Albuz ATR ceramic hollow cone & 2x D series ceramic disk & core. (per side). Front ring only.
Pressure: 1450 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

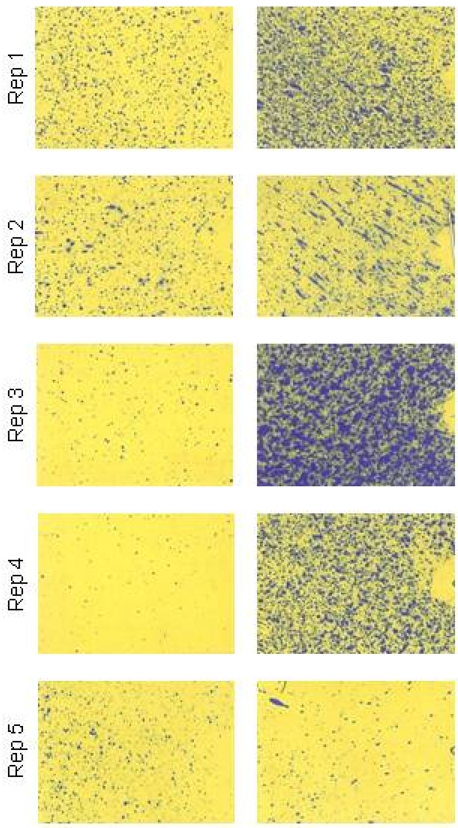


Trt: Atom_concentrate_400ml/ha Du-wett (0.08%)

Male leader lower canopy deposits
Upper surface | Lower surface



Male leader upper canopy deposits
Upper surface | Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

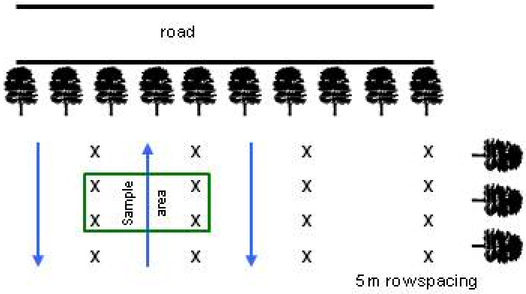
Date: 8th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0 m/s (0 max)
Temperature: 23°

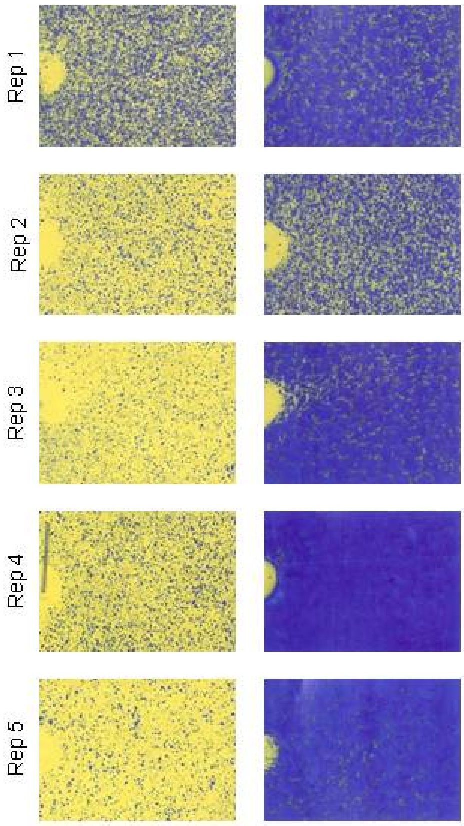
Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

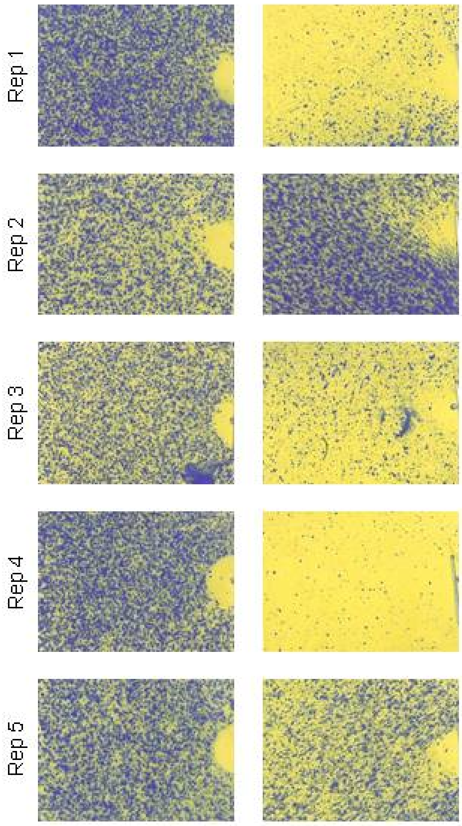


Trt: Silvan_dilute_400ml/ha Du-wett (0.04%)

Centre lower canopy deposits
Upper surface Lower surface



Centre upper canopy deposits
Upper surface Lower surface



Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

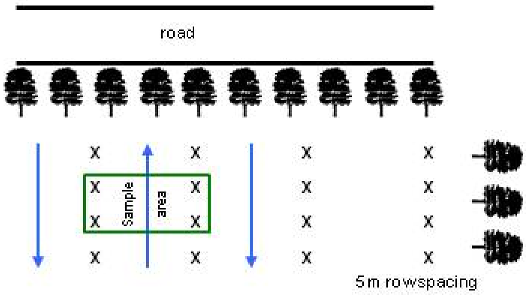
Date: 8th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0 m/s (0 max)
Temperature: 23°

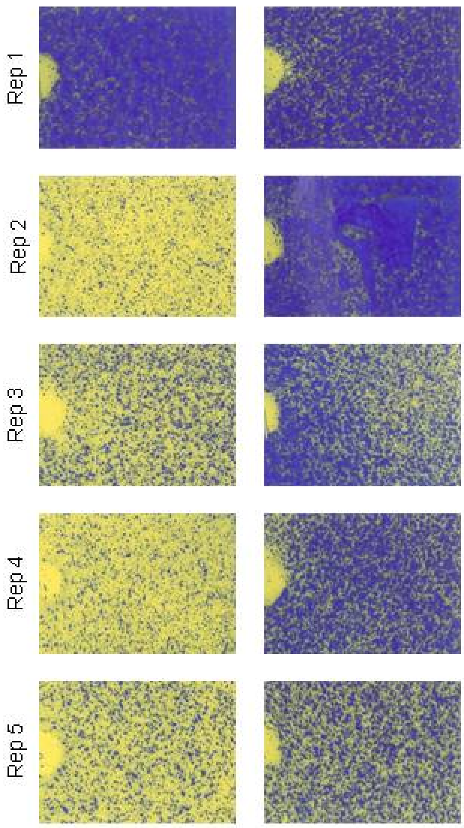
Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

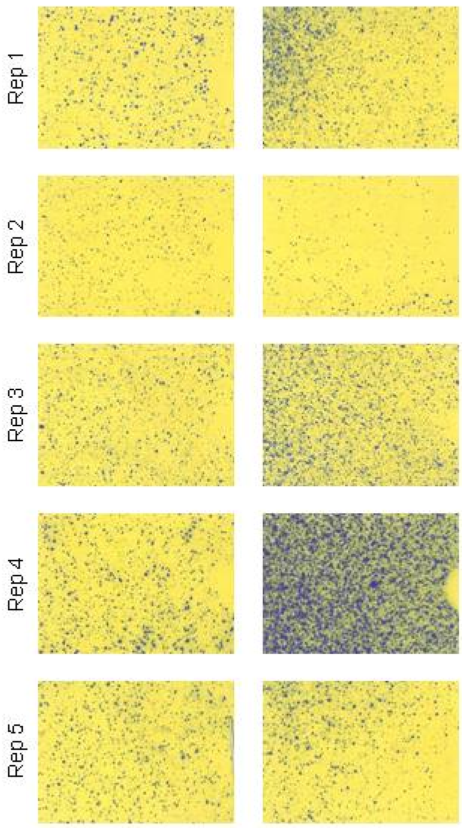


Trt: Silvan_dilute_400ml/ha Du-wett (0.04%)

Male leader lower canopy deposits
Upper surface	Lower surface



Male leader upper canopy deposits
Upper surface	Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

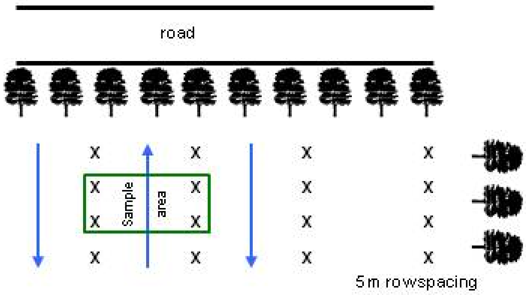
Date: 8th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0.63 m/s (1.5 max)
Temperature: 24°

Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km /hr

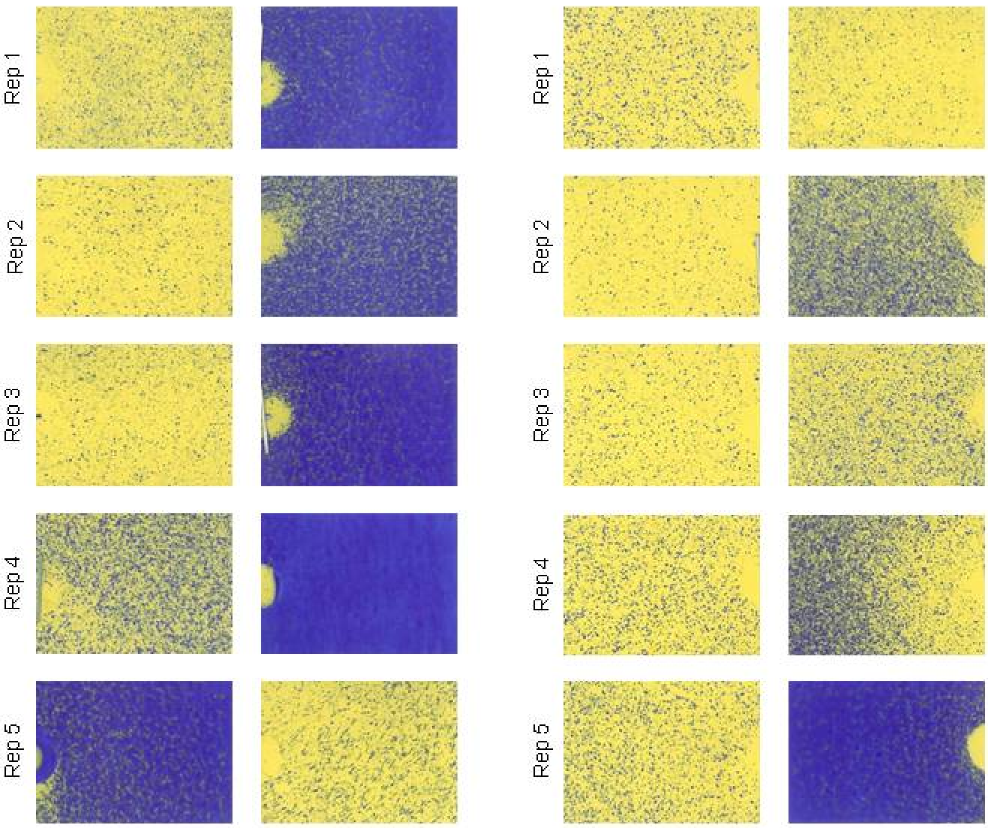
Sprayer travel direction:



Trt: Silvan_concentrate_400ml/ha Du-wett (0.08%)

Centre lower canopy deposits — Upper surface, Lower surface

Centre upper canopy deposits — Upper surface, Lower surface



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

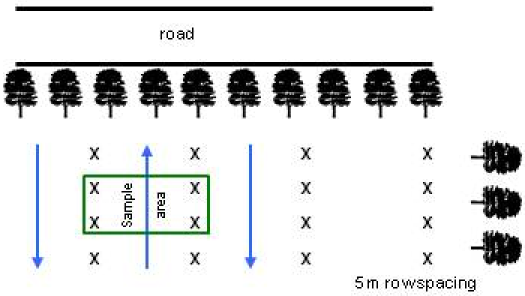
Date: 8th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0.63 m/s (1.5 max)
Temperature: 24°

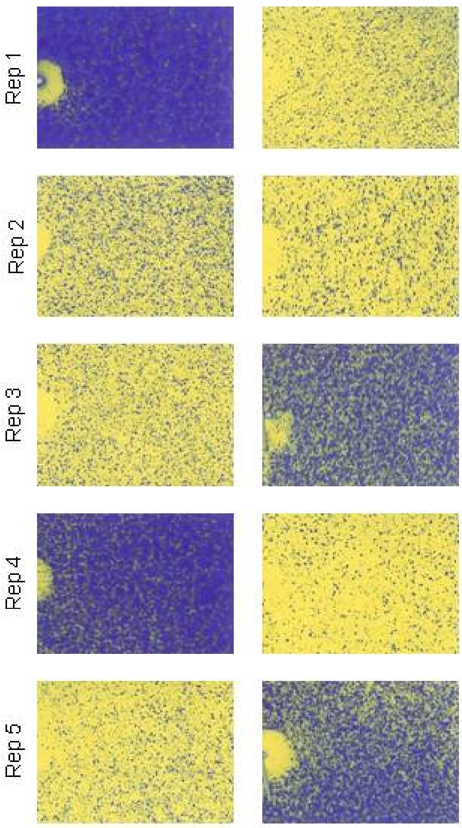
Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

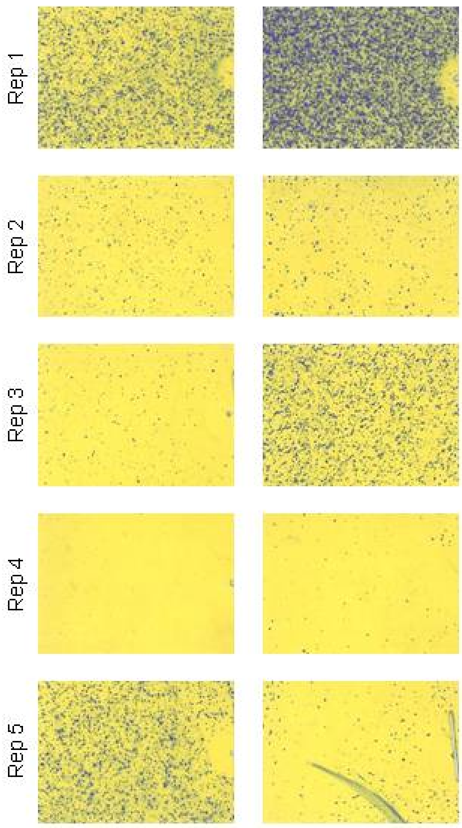


Trt: Silvan_concentrate_400ml/ha Du-wett (0.08%)

Male leader lower canopy deposits
Upper surface Lower surface



Male leader upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

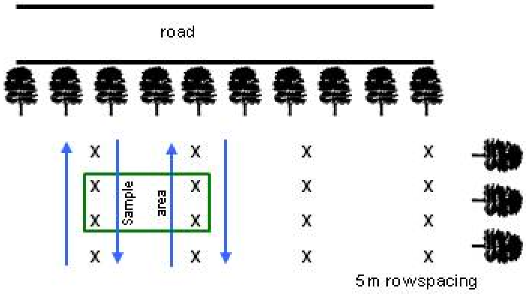
Sprayer: Quantum Mist – 3x QM500 heads

Nozzles: 18x Albuz ATR ceramic hollow cone nozzles
Pressure: 1000 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 5.8 km /hr

Date: 8th Dec 2011

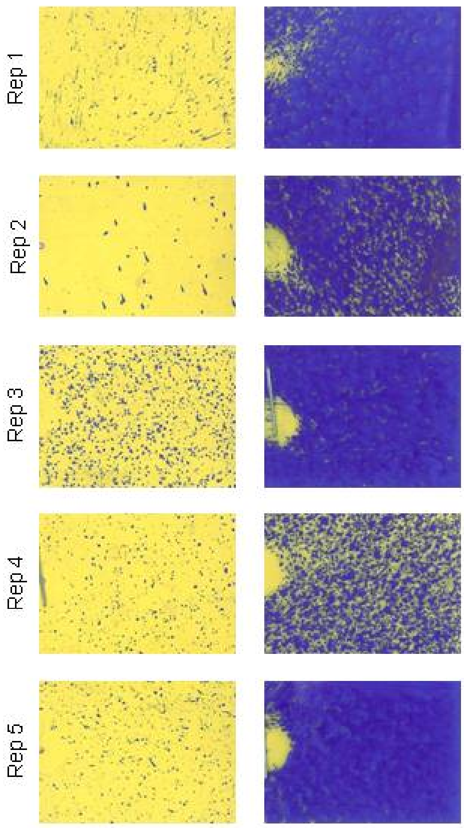
Wind speed (m/s): 0.23 m/s (0.86 max)
Temperature: 26°

Sprayer travel direction:

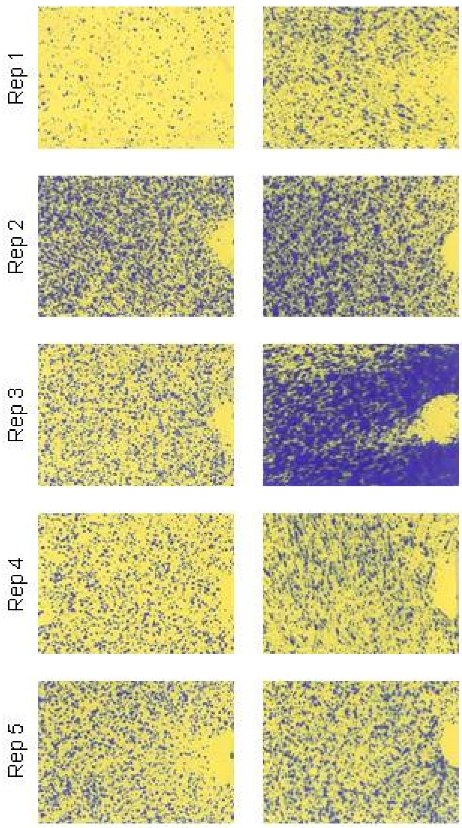


Trt: Quantum mist_dilute_400ml/ha Du-wett (0.04%)

Centre lower canopy deposits
Upper surface Lower surface



Centre upper canopy deposits
Upper surface Lower surface



Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

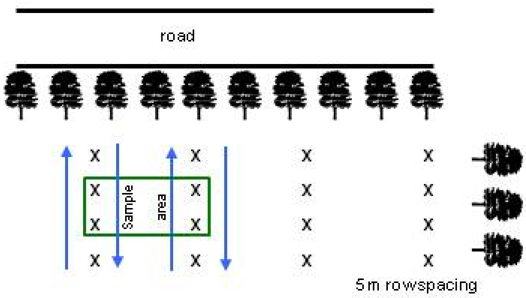
Date: 8th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads

Wind speed (m/s): 0.23 m/s (0.86 max)
Temperature: 26°

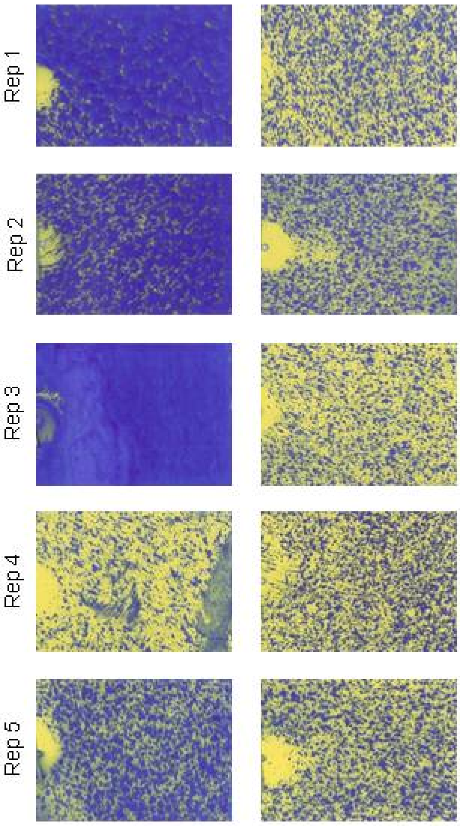
Nozzles: 18x Albuz ATR ceramic hollow cone nozzles
Pressure: 1000 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 5.8 km /hr

Sprayer travel direction:

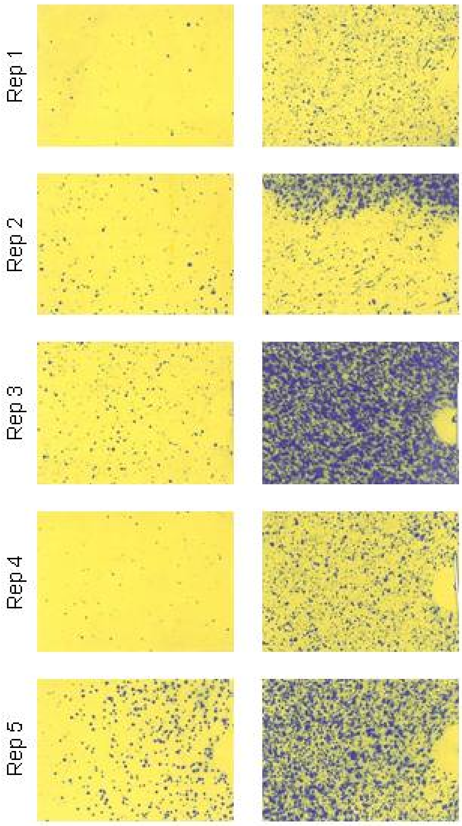


Trt: Quantum mist_dilute_400ml/ha Du-wett (0.04%)

Male leader lower canopy deposits
Upper surface Lower surface



Male leader upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

Sprayer: Quantum Mist – 3x QM500 heads

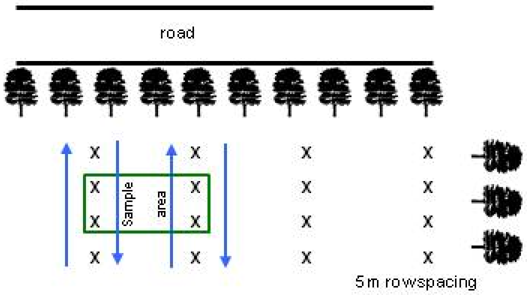
Nozzles: 18x Albuz ATR ceramic hollow cone nozzles
Pressure: 1000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 5.8 km/hr

Date: 8th Dec 2011

Wind speed (m/s): 0.68 m/s (2.31 max)
Temperature: 21°

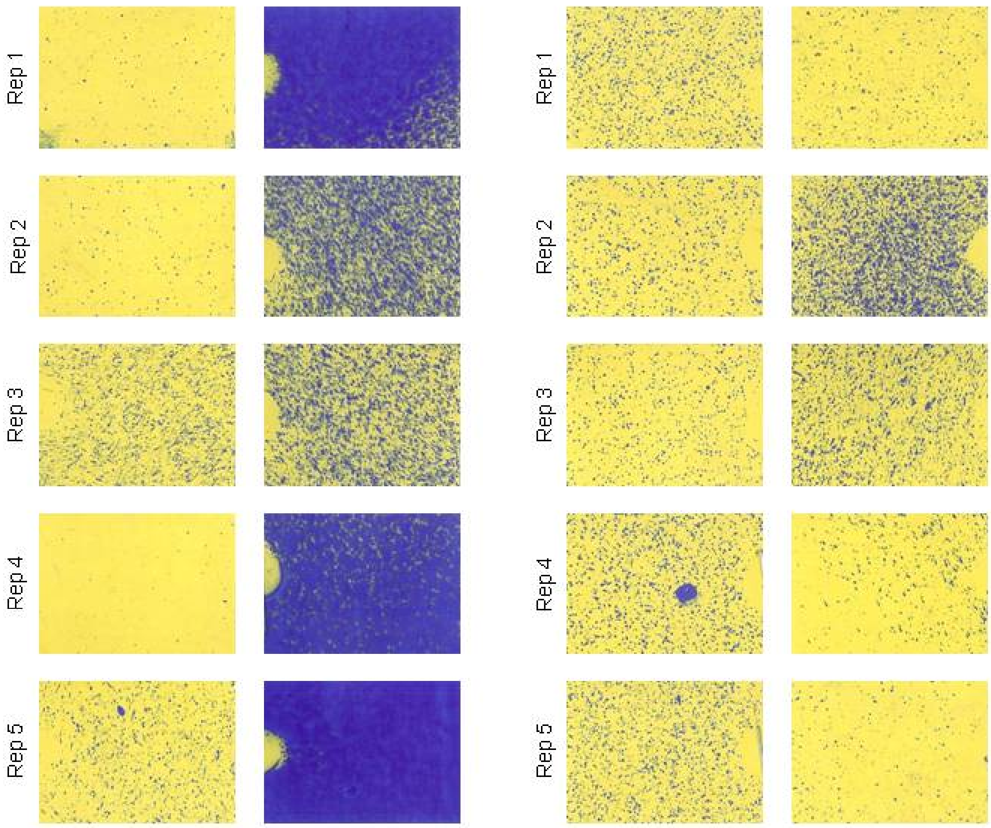
Trt: Quantum mist_concentrate_400ml/ha Du-wett (0.08%)

Sprayer travel direction:



Centre lower canopy deposits — Upper surface | Lower surface

Centre upper canopy deposits — Upper surface | Lower surface



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

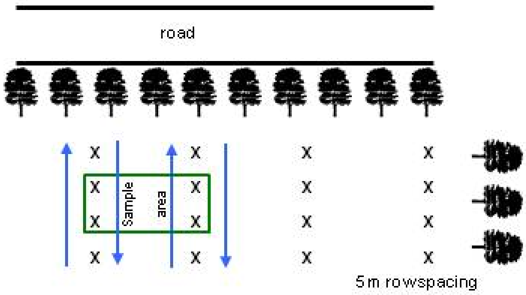
Date: 8th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads

Nozzles: 18x Albuz ATR ceramic hollow cone nozzles
Pressure: 1000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 5.8 km/hr

Wind speed (m/s): 0.68 m/s (2.31 max)
Temperature: 21°

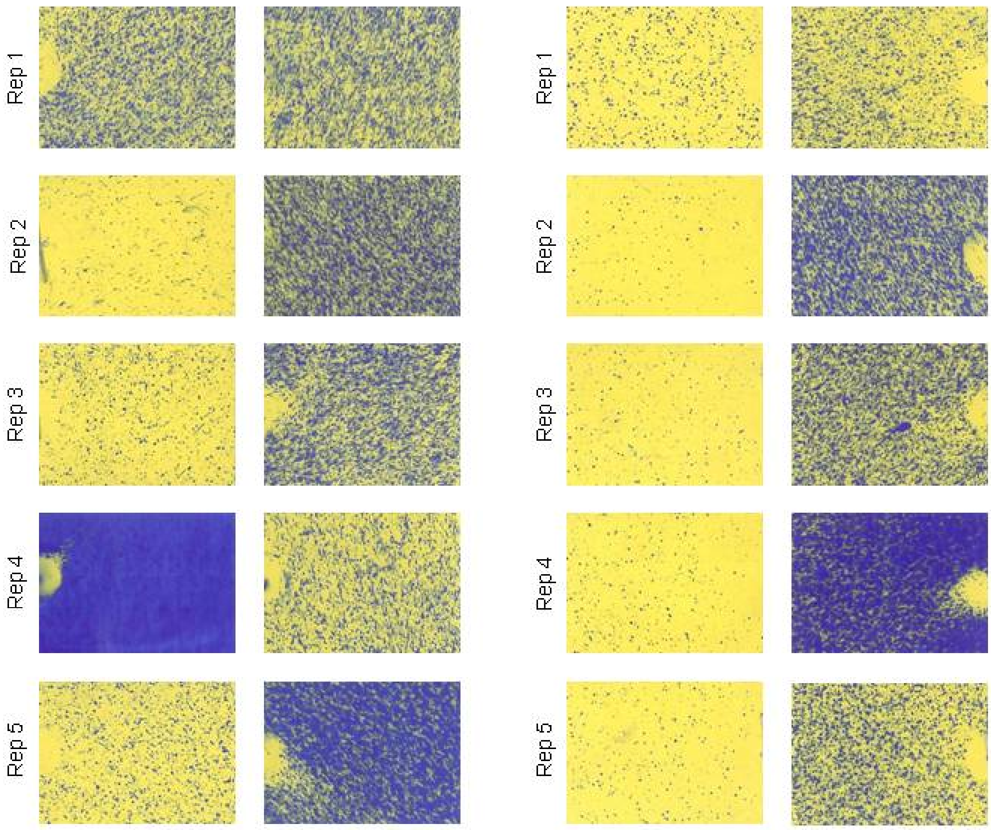
Sprayer travel direction:



Trt: Quantum mist_concentrate_400ml/ha Du-wett (0.08%)

Male leader lower canopy deposits — Upper surface / Lower surface

Male leader upper canopy deposits — Upper surface / Lower surface



PPC NZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

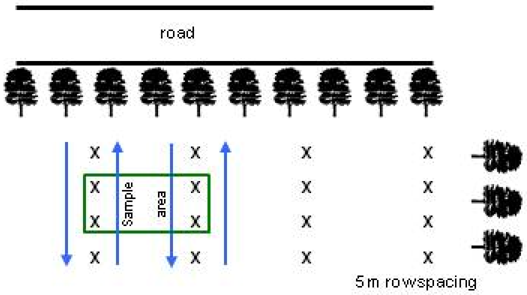
Date: 8th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.6m below canopy.

Wind speed (m/s): 0.47 m/s (1.24 max)
Temperature: 26°

Nozzles: 18x ESS nozzles
Pressure:
Water rate (L/ha): 200L
Travel speed (km/h): 5 km/hr

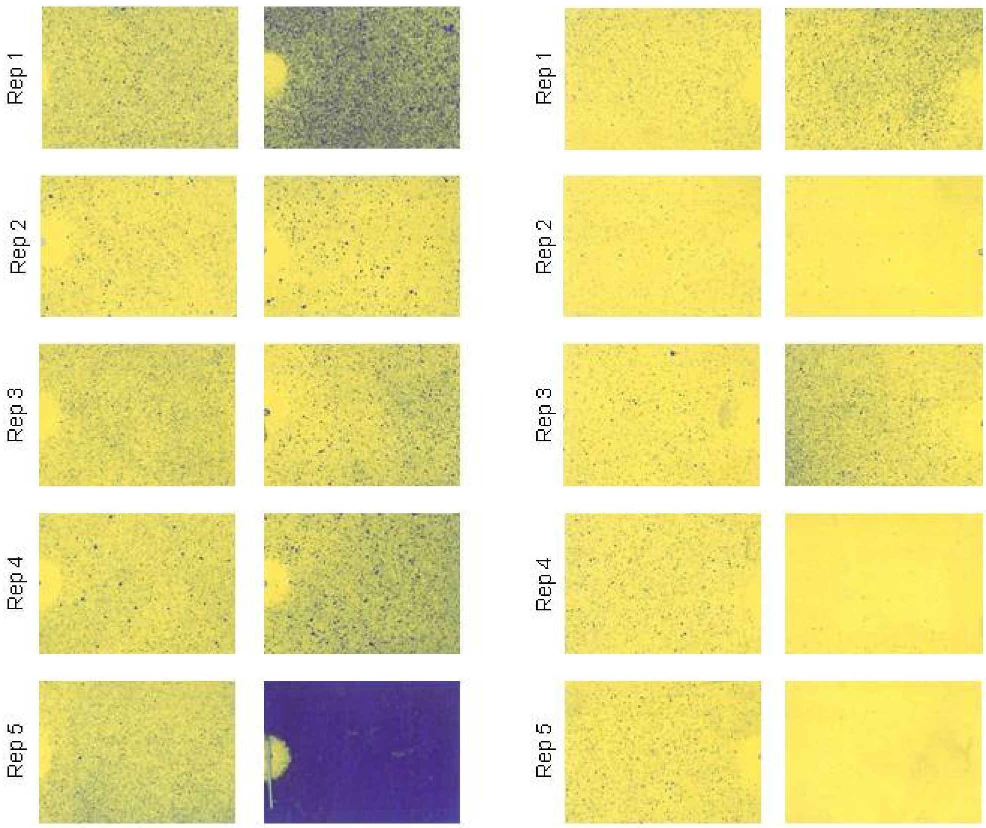
Sprayer travel direction:



Trt: Electrostatic_run1_100ml/100L Du-wett (0.1%)

Centre lower canopy deposits
Upper surface Lower surface

Centre upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry
NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

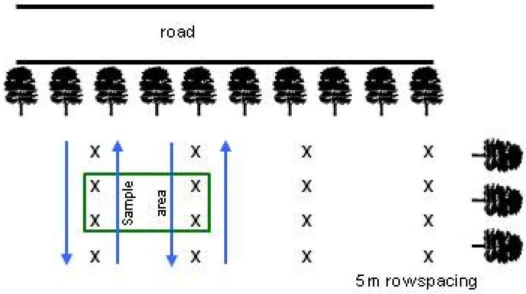
Date: 8th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.6m below canopy.

Wind speed (m/s): 0.47 m/s (1.24 max)
Temperature: 26°

Nozzles: 18x ESS nozzles
Pressure:
Water rate (L/ha): 200L
Travel speed (km/h): 5 km/hr

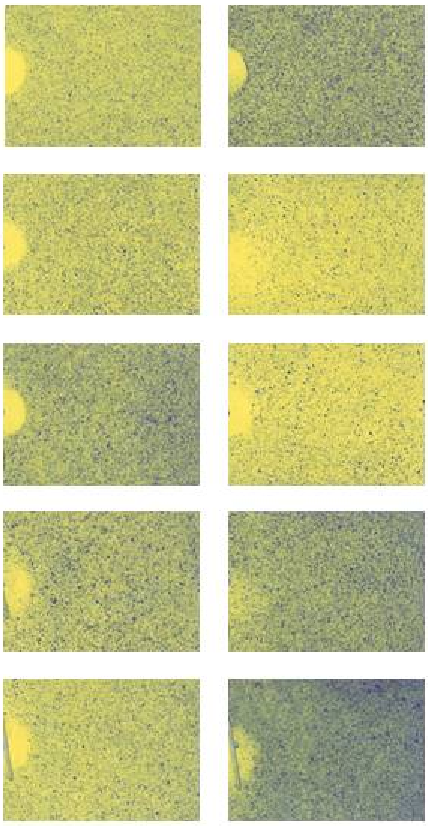
Sprayer travel direction:



Trt: Electrostatic_run1_100ml/100L Du-wett (0.1%)

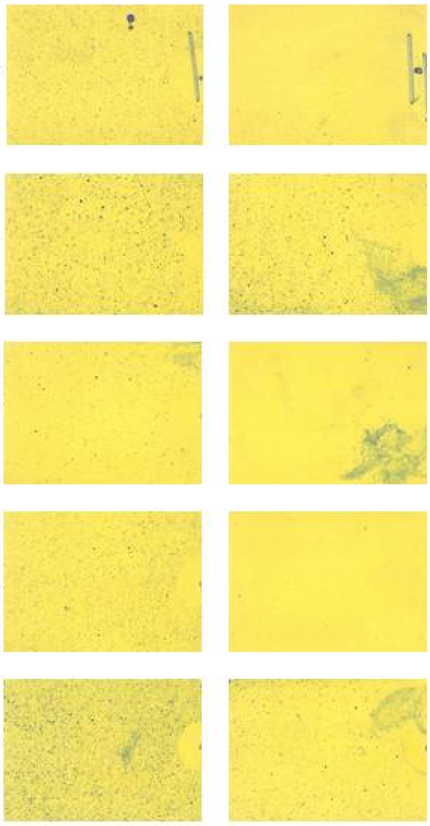
Male leader lower canopy deposits
Upper surface Lower surface

Rep 1
Rep 2
Rep 3
Rep 4
Rep 5



Male leader upper canopy deposits
Upper surface Lower surface

Rep 1
Rep 2
Rep 3
Rep 4
Rep 5



Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

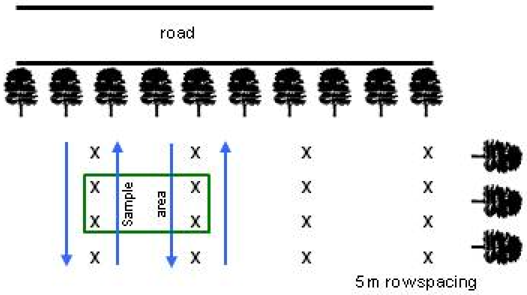
Date: 8th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.6m below canopy.

Wind speed (m/s): 0.03 m/s (0.22 max)
Temperature: 22°

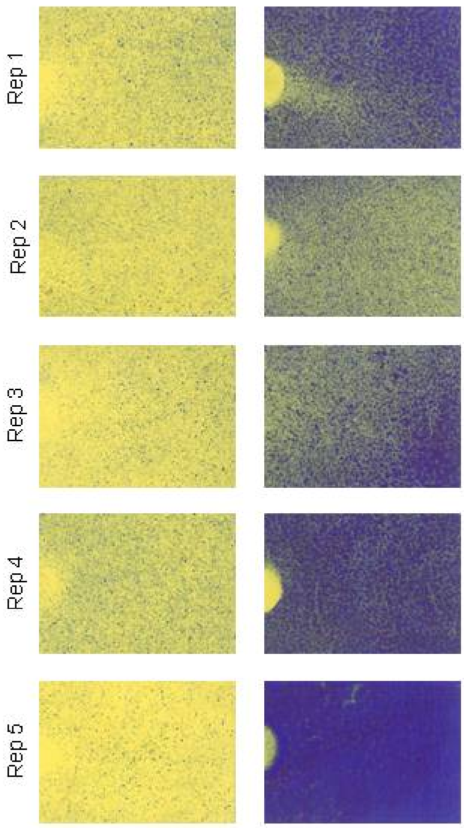
Nozzles: 18x ESS nozzles
Pressure:
Water rate (L/ha): 238L
Travel speed (km/h): 4.2 km/hr

Sprayer travel direction:

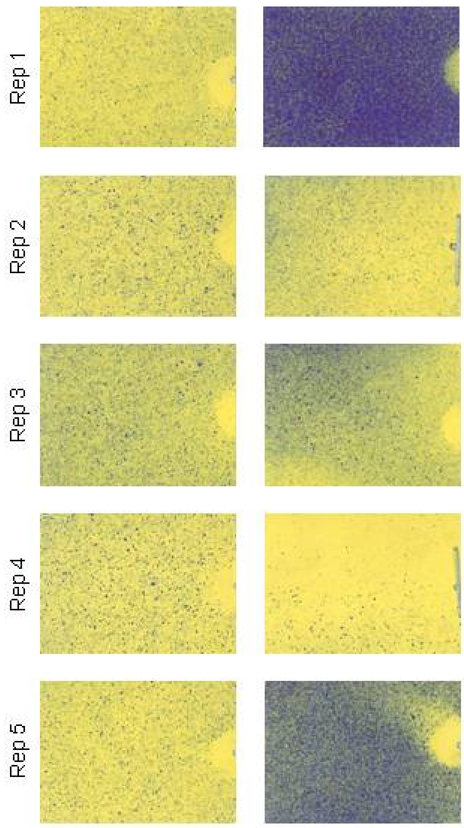


Trt: Electrostatic_run2_100ml/100L Du-wett (0.1%)

Centre lower canopy deposits
Upper surface Lower surface



Centre upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial1_Ground based sprays, on Hayward foliage canopy using water sensitive papers.

Location: Huse Lane, Rangiuru.

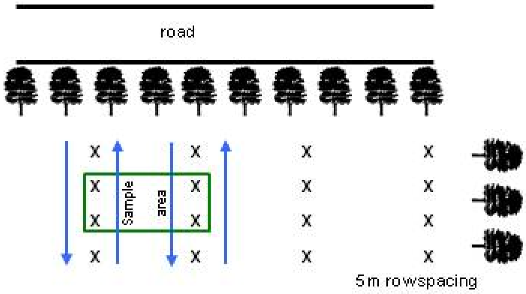
Date: 8th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.6m below canopy.

Wind speed (m/s): 0.03 m/s (0.22 max)
Temperature: 22°

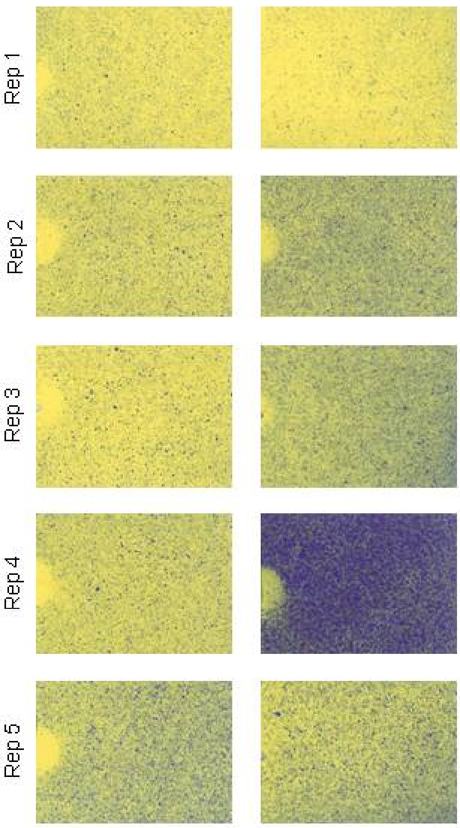
Nozzles: 18x ESS nozzles
Pressure:
Water rate (L/ha): 238L
Travel speed (km/h): 4.2 km/hr

Sprayer travel direction:

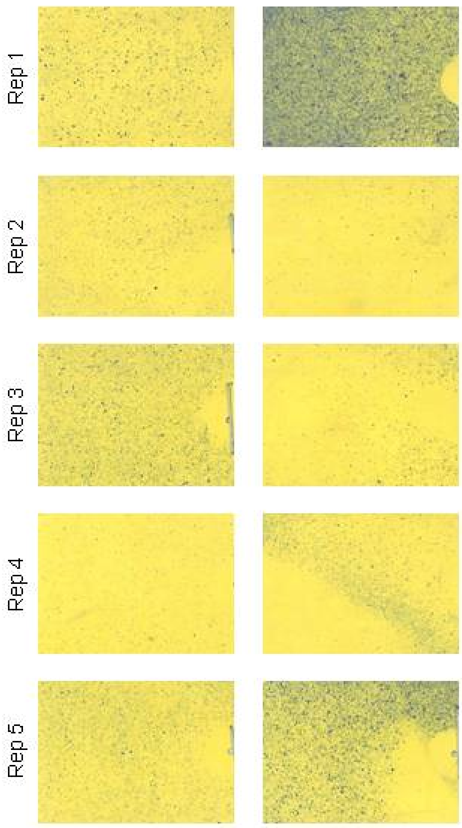


Trt: Electrostatic_run2_100ml/100L Du-wett (0.1%)

Male leader lower canopy deposits
Upper surface Lower surface



Male leader upper canopy deposits
Upper surface Lower surface



PPC NZ Plant Protection Chemistry NEW ZEALAND

APPENDIX 5
Water sensitive paper record of sprayers assessed in Study #2

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

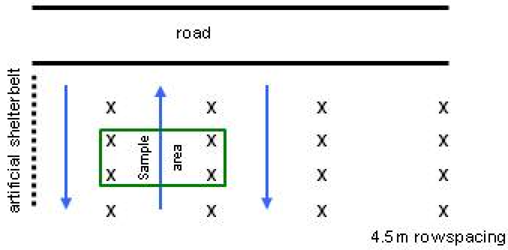
Date: 9th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.5 m/s (1.1 max)
Temperature: 24°

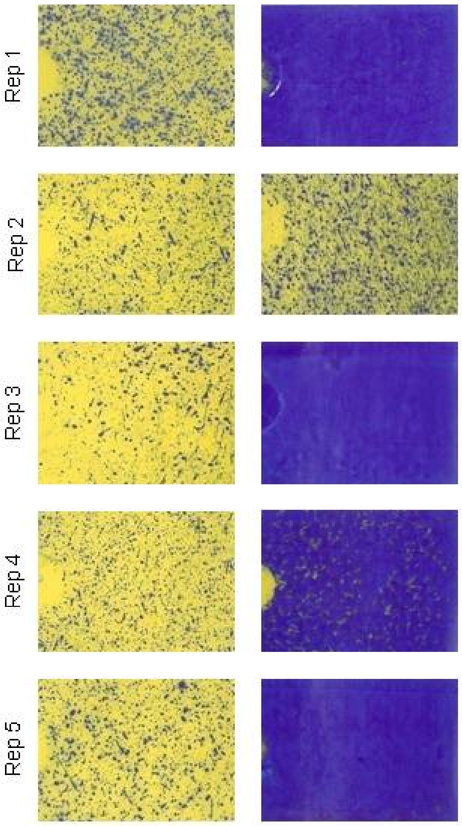
Nozzles: 4x Albuz ATR ceramic hollow cone & 1x D series ceramic disk & core. (per side). Twin rings operating.
Pressure: 1480 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:

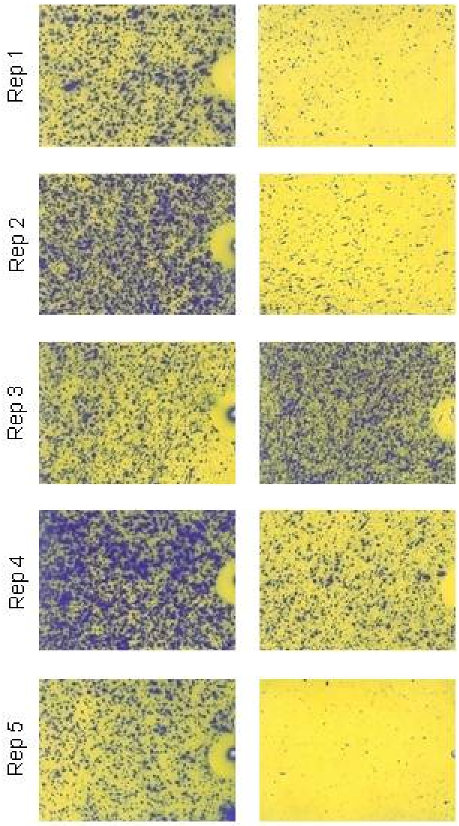


Trt: Atom_dilute_400ml/ha Du-wett (0.04%)

Centre lower canopy deposits
Upper surface Lower surface



Centre upper canopy deposits
Upper surface Lower surface



Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

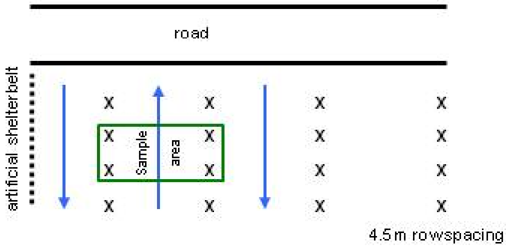
Date: 9th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.5 m/s (1.1 max)
Temperature: 24°

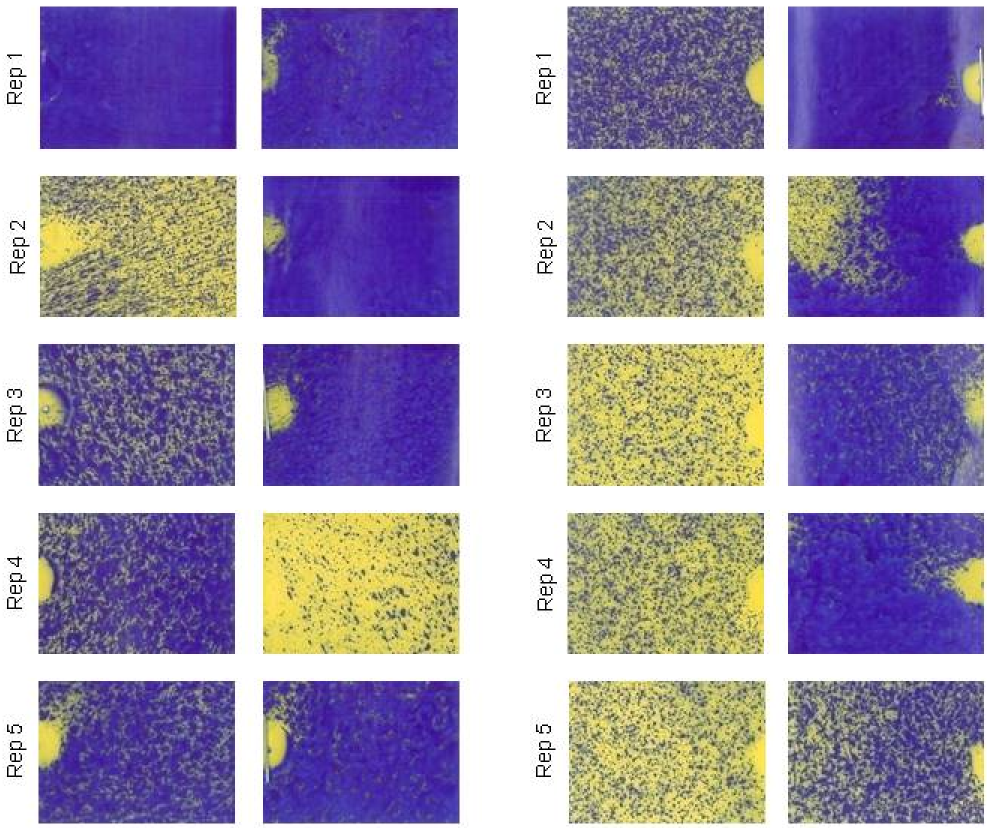
Nozzles: 4x Albuz ATR ceramic hollow cone & 1x D series ceramic disk & core. (per side). Twin rings operating
Pressure: 1480 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Sprayer travel direction:



Trt: Atom_dilute_400ml/ha Du-wett (0.04%)

Leader lower canopy deposits		**Leader upper canopy deposits**	
Upper surface	Lower surface	Upper surface	Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

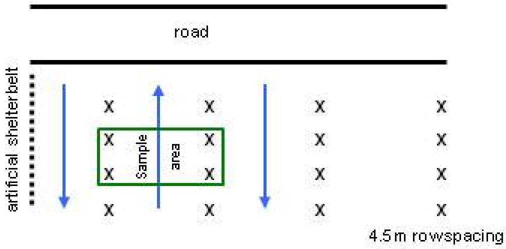
Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Nozzles: 4x Albuz ATR ceramic hollow cone & 1x D series ceramic disk & core. (per side). Front ring only.
Pressure: 2000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

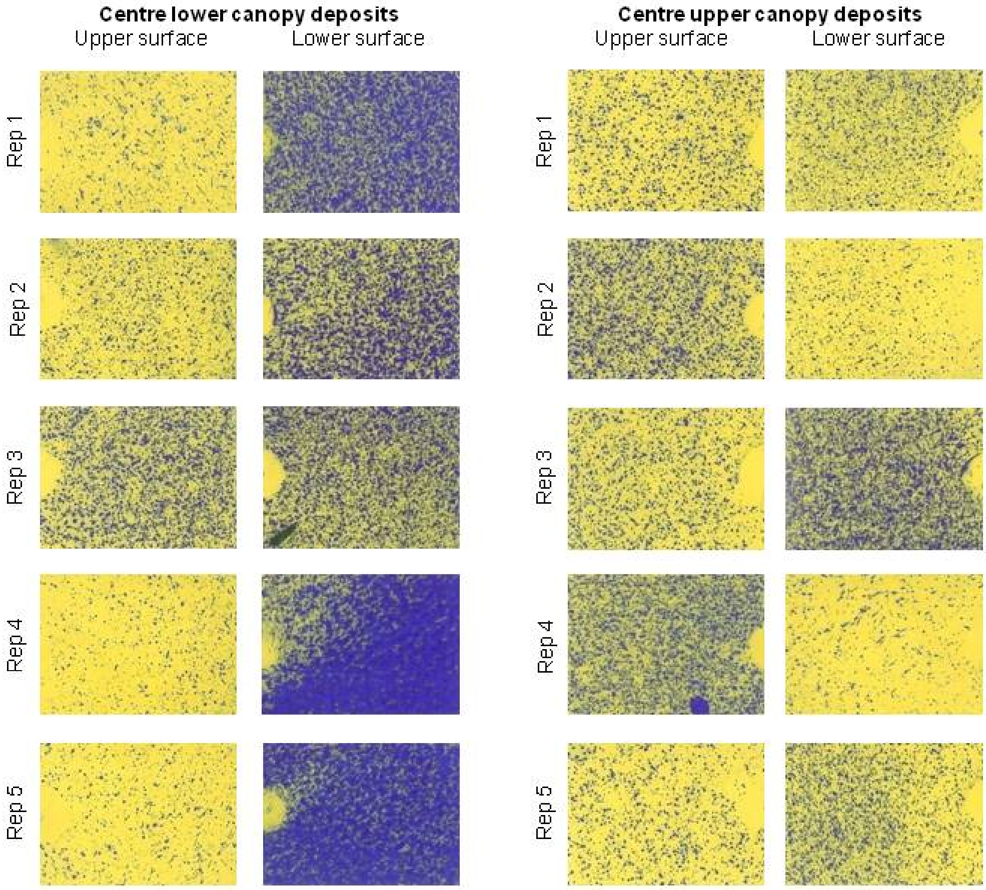
Date: 9th Dec 2011

Wind speed (m/s): 0.9 m/s (2.6 max)
Temperature: 25°

Sprayer travel direction:



Trt: Atom_concentrate_400ml/ha Du-wett (0.08%)



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

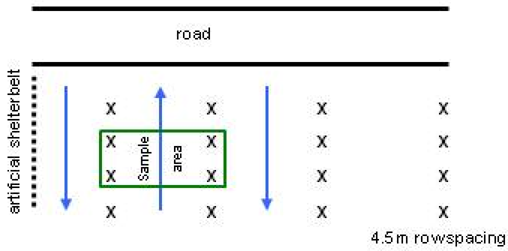
Date: 9th Dec 2011

Sprayer: Atom 2000 Turbo Evo, Modena.
Arivac front entry 36 inch fan. Twin nozzle ring.

Wind speed (m/s): 0.9 m/s (2.6 max)
Temperature: 25°

Nozzles: 4x Albuz ATR ceramic hollow cone & 1x D series ceramic disk & core. (per side). Front ring only
Pressure: 2000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

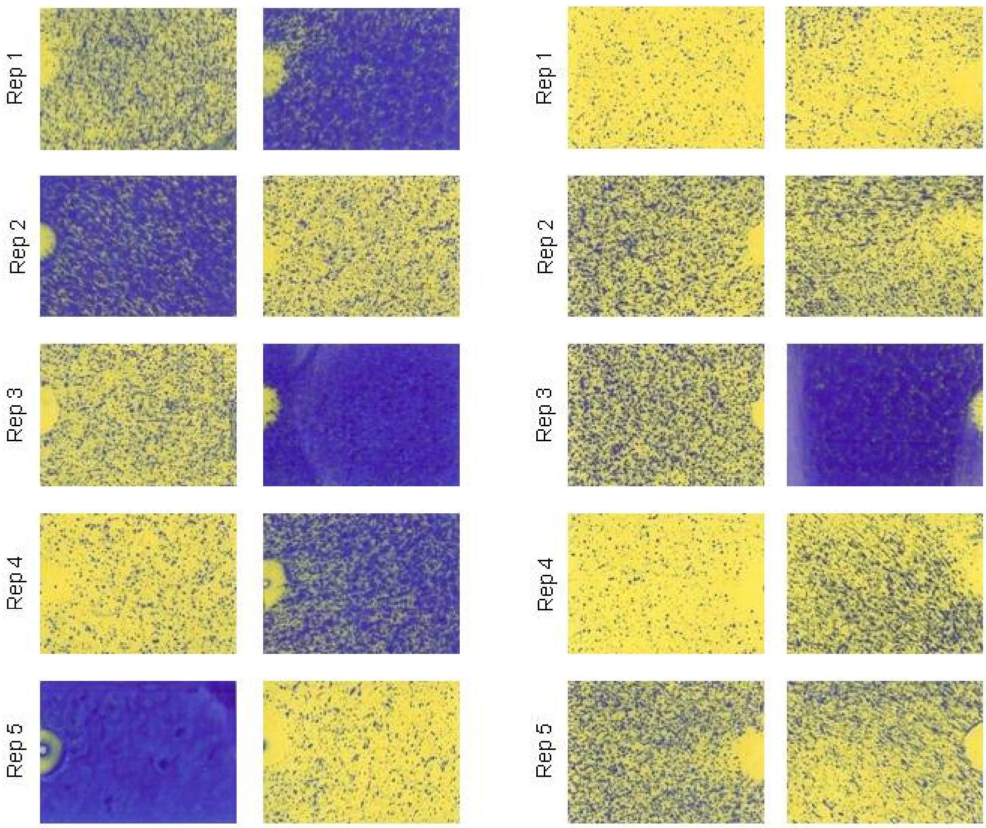
Sprayer travel direction:



Trt: Atom_concentrate_400ml/ha Du-wett (0.08%)

Leader lower canopy deposits
Upper surface Lower surface

Leader upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry
NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

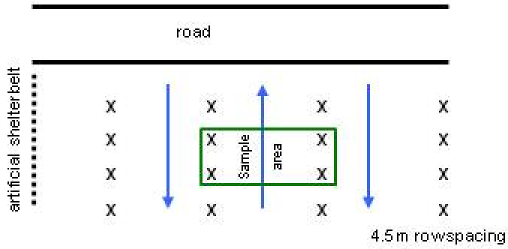
Date: 9th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Wind speed (m/s): 0.3 m/s (0.8 max)
Temperature: 21°

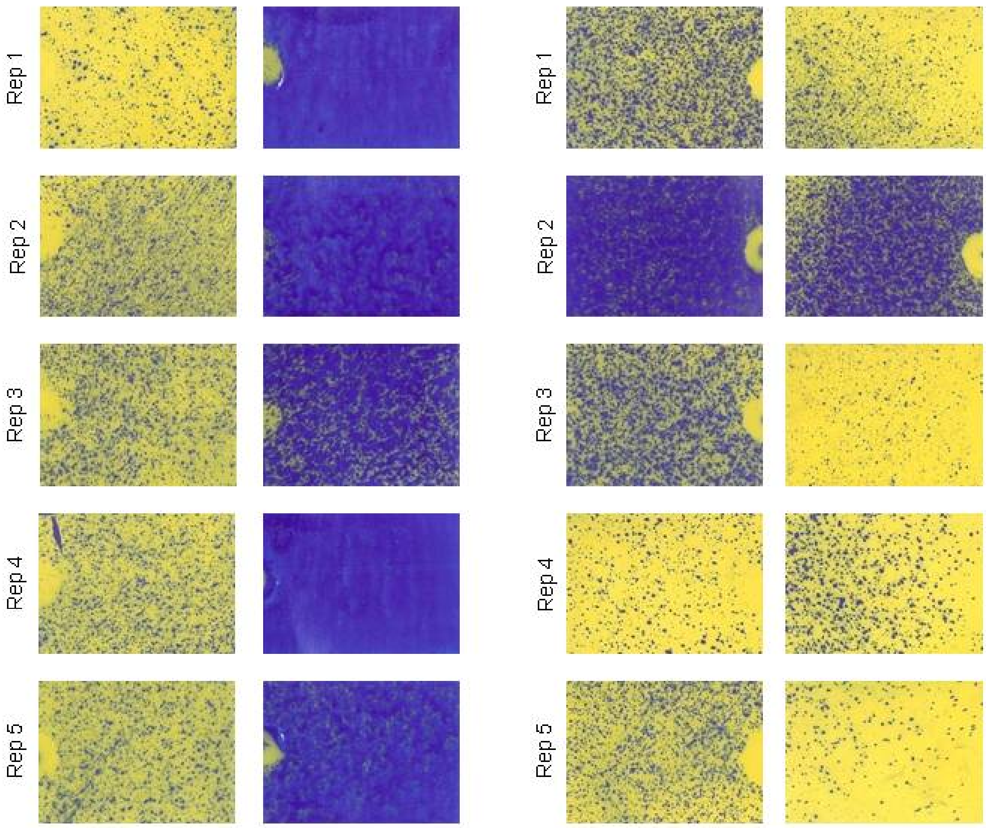
Sprayer travel direction:



Trt: Silvan_dilute_400ml/ha Du-wett (0.04%)

Centre lower canopy deposits — Upper surface, Lower surface

Centre upper canopy deposits — Upper surface, Lower surface



PPC NZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

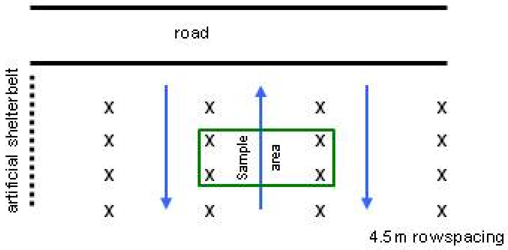
Date: 9th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0.3 m/s (0.8 max)
Temperature: 21°

Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

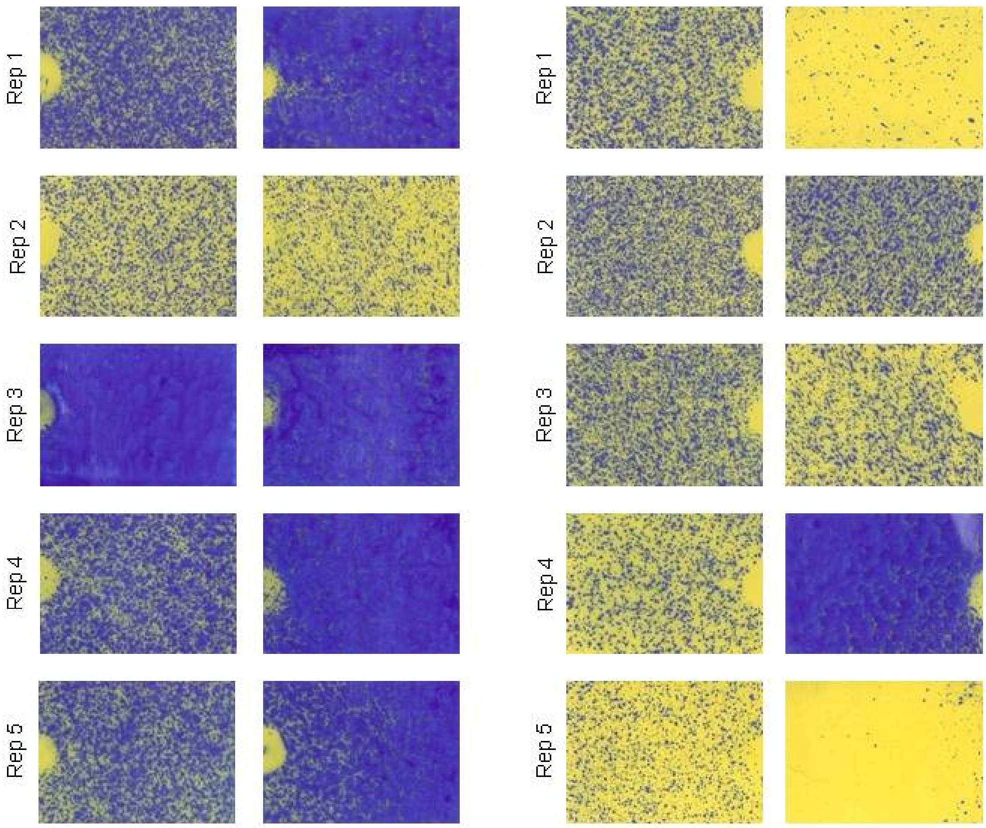
Sprayer travel direction:



Trt: Silvan_dilute_400ml/ha Du-wett (0.04%)

Leader lower canopy deposits — Upper surface / Lower surface

Leader upper canopy deposits — Upper surface / Lower surface



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

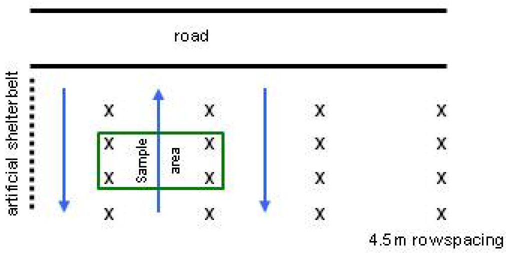
Location: Te Matai Rd, Te Puke.

Date: 9th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).
Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

Wind speed (m/s): 0.5 m/s (1.7 max)
Temperature: 26°

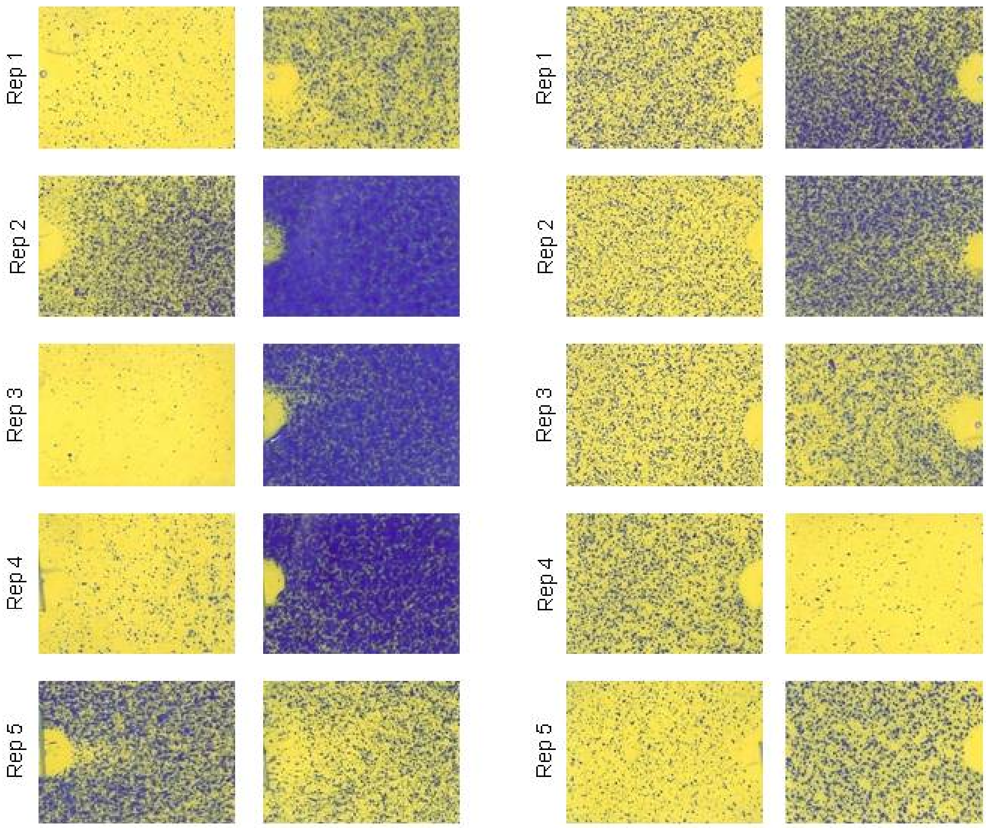
Sprayer travel direction:



Trt: Silvan_concentrate_400ml/ha Du-wett (0.08%)

Centre lower canopy deposits — Upper surface / Lower surface

Centre upper canopy deposits — Upper surface / Lower surface



Plant Protection Chemistry
NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

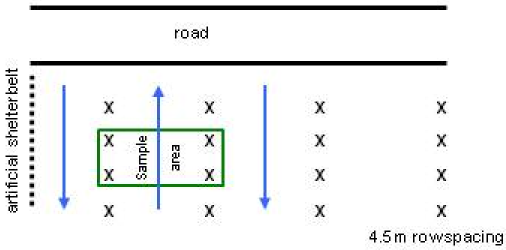
Date: 9th Dec 2011

Sprayer: Silvan kiwifruit sprayer. 4x split air ducts (per side).

Wind speed (m/s): 0.5 m/s (1.7 max)
Temperature: 26°

Nozzles: ATR equivalent.
Pressure: 1900 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

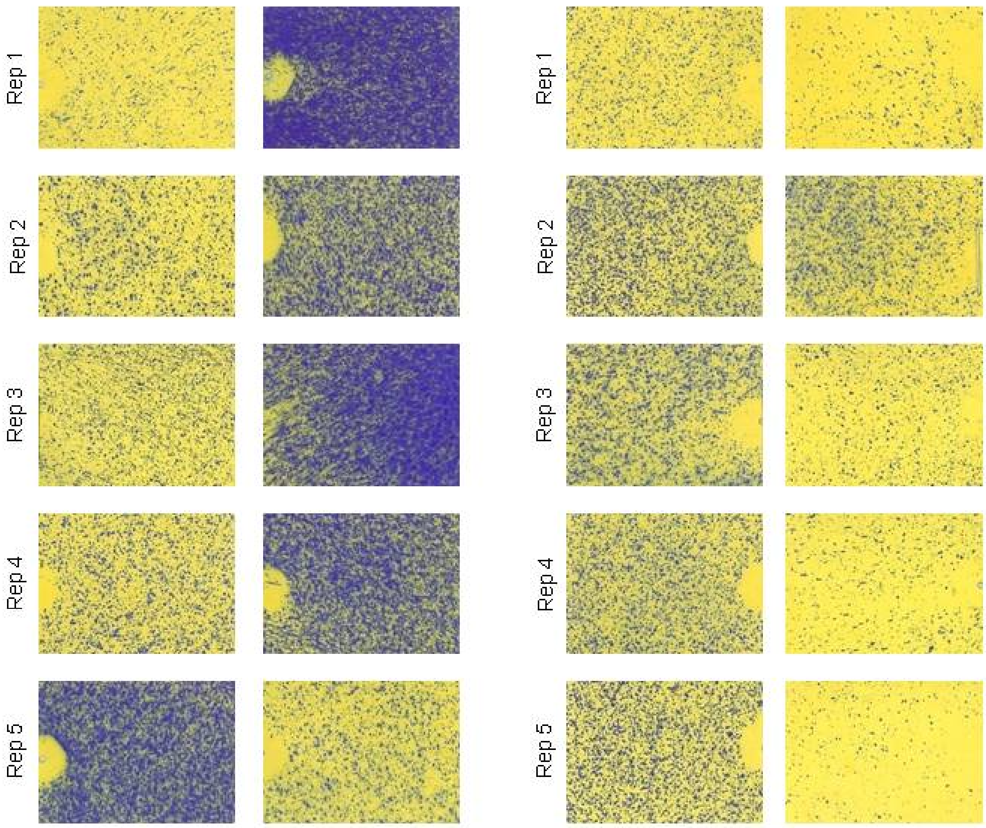
Sprayer travel direction:



Trt: Silvan_concentrate_400ml/ha Du-wett (0.08%)

Leader lower canopy deposits — Upper surface, Lower surface

Leader upper canopy deposits — Upper surface, Lower surface



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

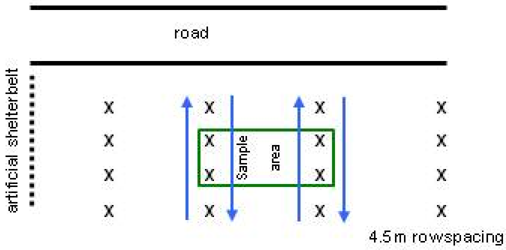
Date: 9th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads.

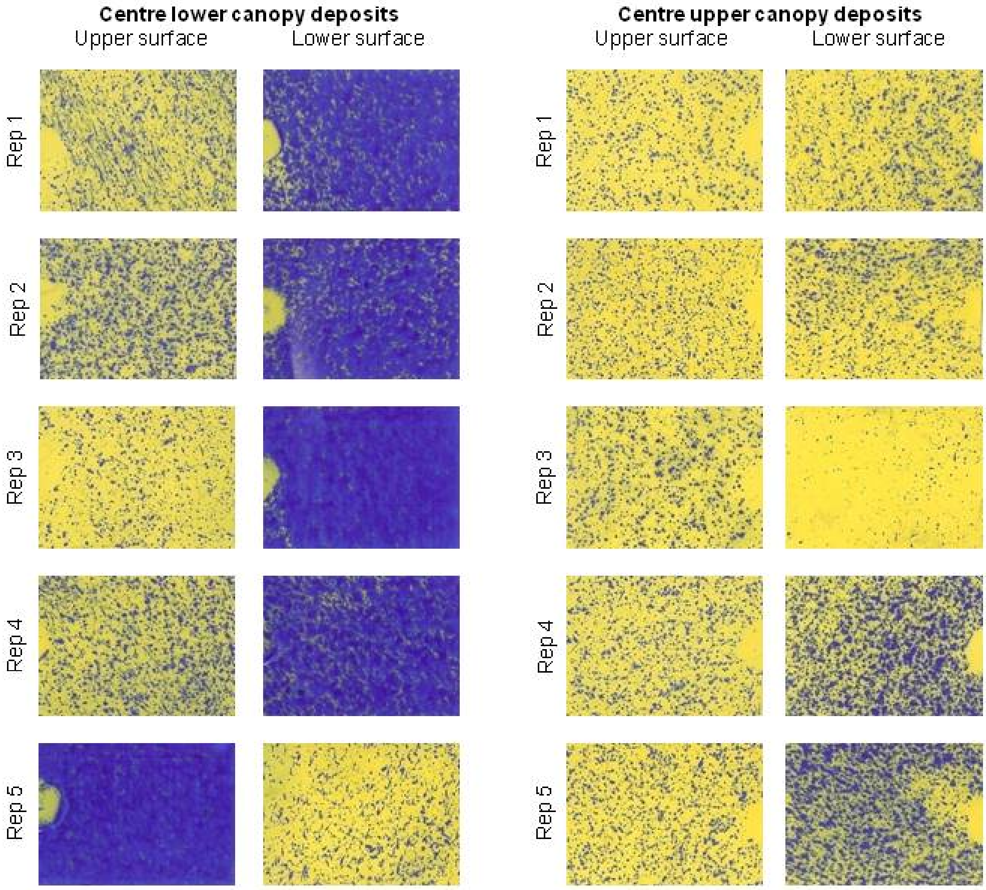
Nozzles: 18x Albuz ATR ceramic hollow cone nozzles.
Pressure: 1000 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km/hr

Wind speed (m/s): 1.4 m/s (2.5 max)
Temperature: 26°

Sprayer travel direction:



Trt: Quantum mist_dilute_400ml/ha Du-wett (0.04%)



PPCNZ Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

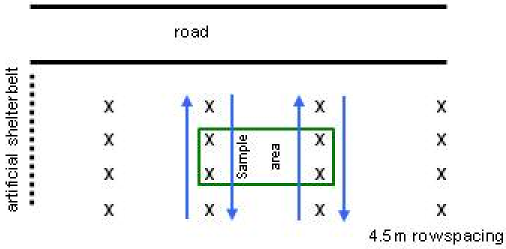
Date: 9th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads.

Nozzles: 18x Albuz ATR ceramic hollow cone nozzles.
Pressure: 1000 kpa
Water rate (L/ha): 1000L
Travel speed (km/h): 6 km /hr

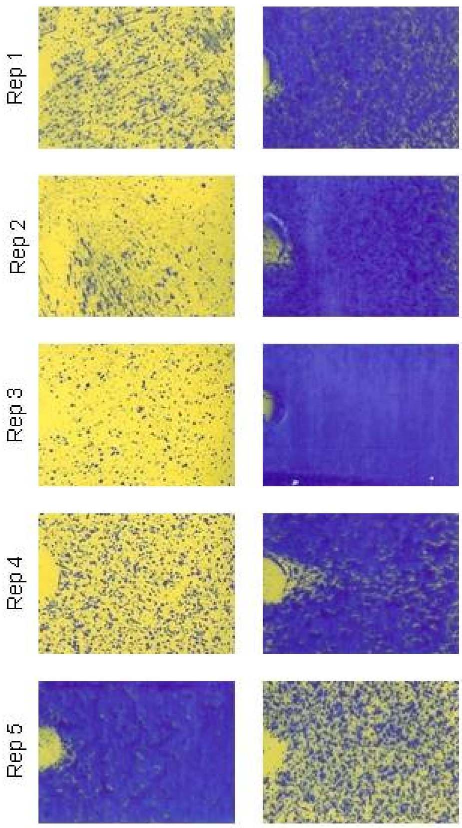
Wind speed (m/s): 1.4 m/s (2.5 max)
Temperature: 26°

Sprayer travel direction:

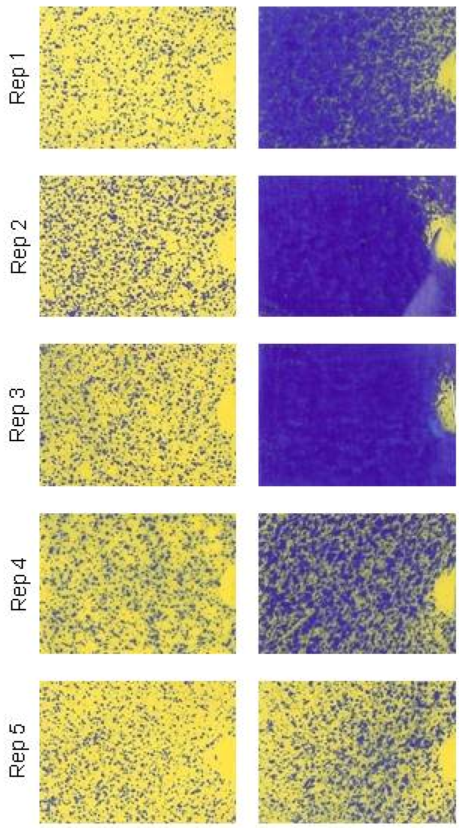


Trt: Quantum mist_dilute_400ml/ha Du-wett (0.04%)

Leader lower canopy deposits
Upper surface Lower surface



Leader upper canopy deposits
Upper surface Lower surface



Plant Protection Chemistry
NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

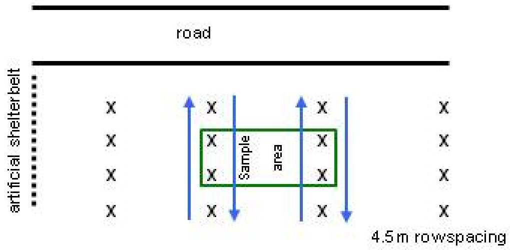
Date: 9th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads.

Wind speed (m/s): 0.4 m/s (1 max)
Temperature: 24°

Nozzles: 18x Albuz ATR ceramic hollow cone nozzles.
Pressure: 1000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km/hr

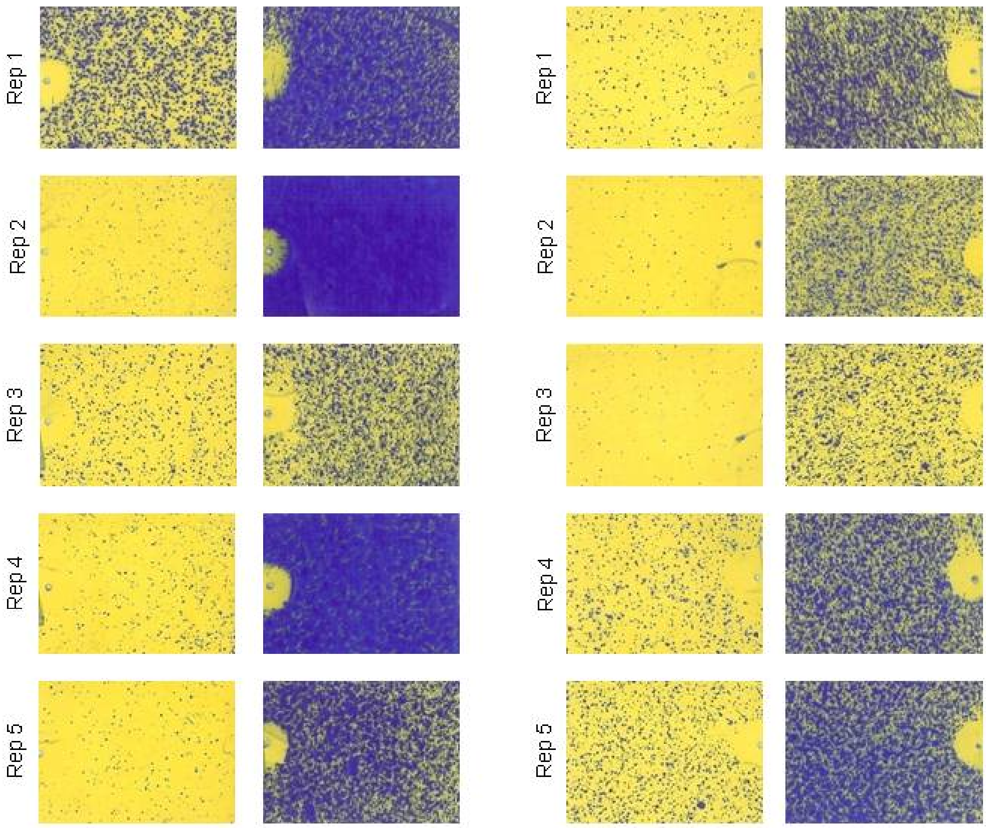
Sprayer travel direction:



Trt: Quantum mist_concentrate_400ml/ha Du-wett (0.08%)

Centre lower canopy deposits Upper surface Lower surface

Centre upper canopy deposits Upper surface Lower surface



Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

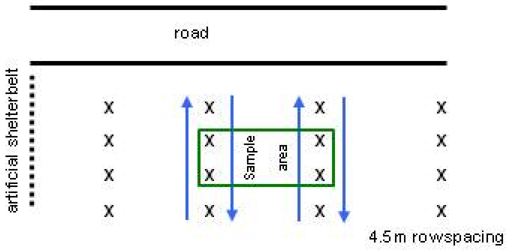
Date: 9th Dec 2011

Sprayer: Quantum Mist – 3x QM500 heads.

Wind speed (m/s): 0.4 m/s (1 max)
Temperature: 24°

Nozzles: 18x Albuz ATR ceramic hollow cone nozzles.
Pressure: 1000 kpa
Water rate (L/ha): 500L
Travel speed (km/h): 6 km /hr

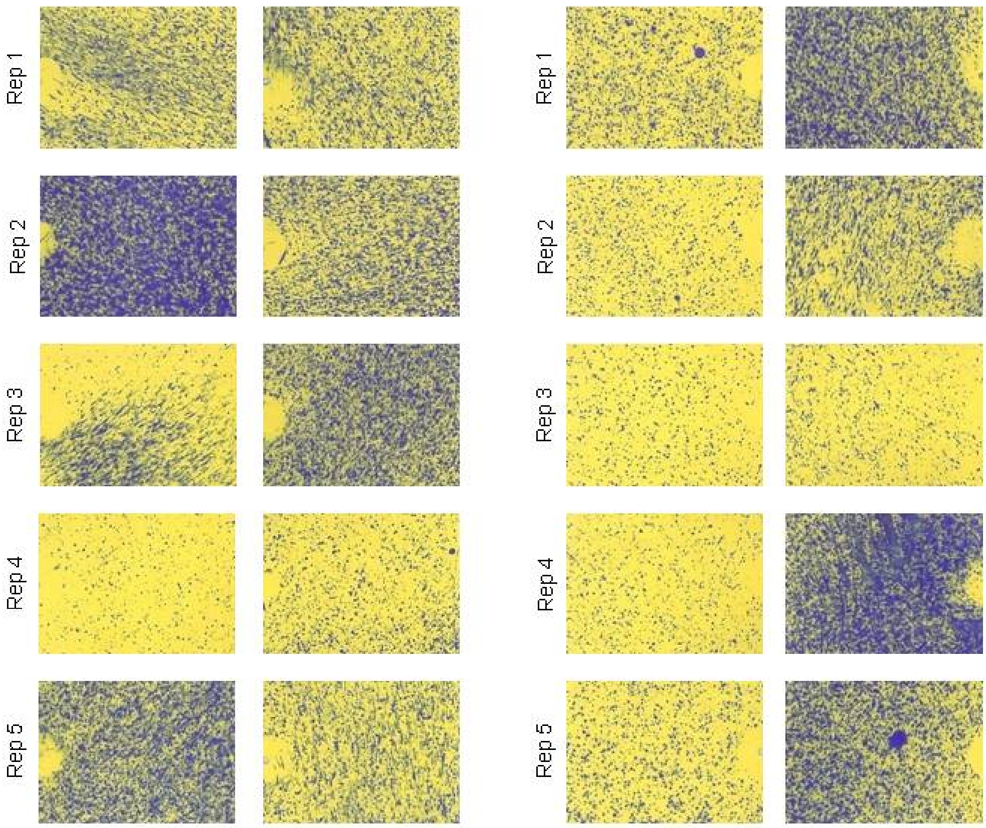
Sprayer travel direction:



Trt: Quantum mist_concentrate_400ml/ha Du-wett (0.08%)

Leader lower canopy deposits — Upper surface / Lower surface

Leader upper canopy deposits — Upper surface / Lower surface



Plant Protection Chemistry
NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

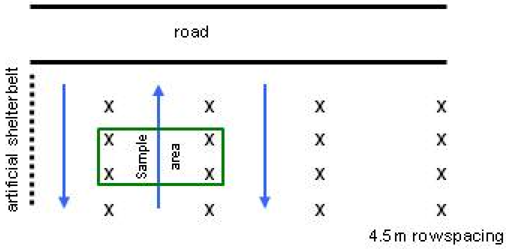
Date: 9th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.8m below canopy.

Wind speed (m/s): 0.5 m/s (1.4 max)
Temperature: 25°

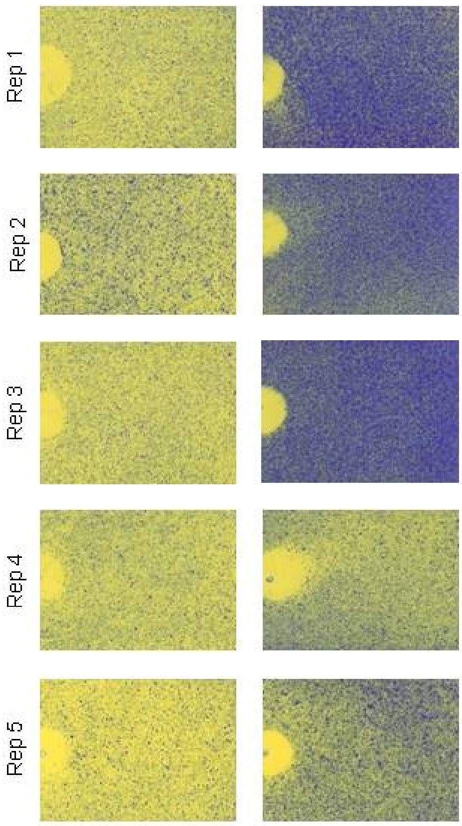
Nozzles: 28x ESS nozzles.
Pressure:
Water rate (L/ha): 150L
Travel speed (km/h): 5 km/hr

Sprayer travel direction:

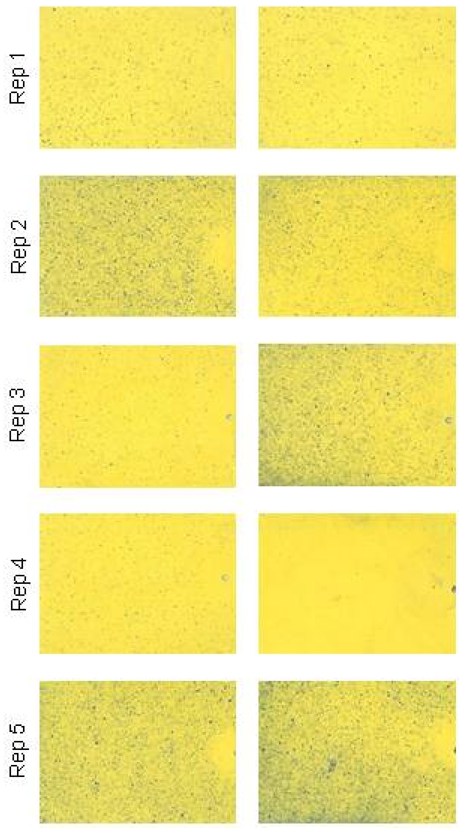


Trt: Electrostatic_run1_100ml/100L Du-wett (0.1%)

Centre lower canopy deposits
Upper surface Lower surface



Centre upper canopy deposits
Upper surface Lower surface



PPC NZ Plant Protection Chemistry NEW ZEALAND

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Travel speed (km/h): 5 km/hr

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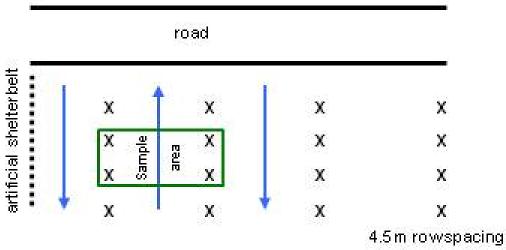
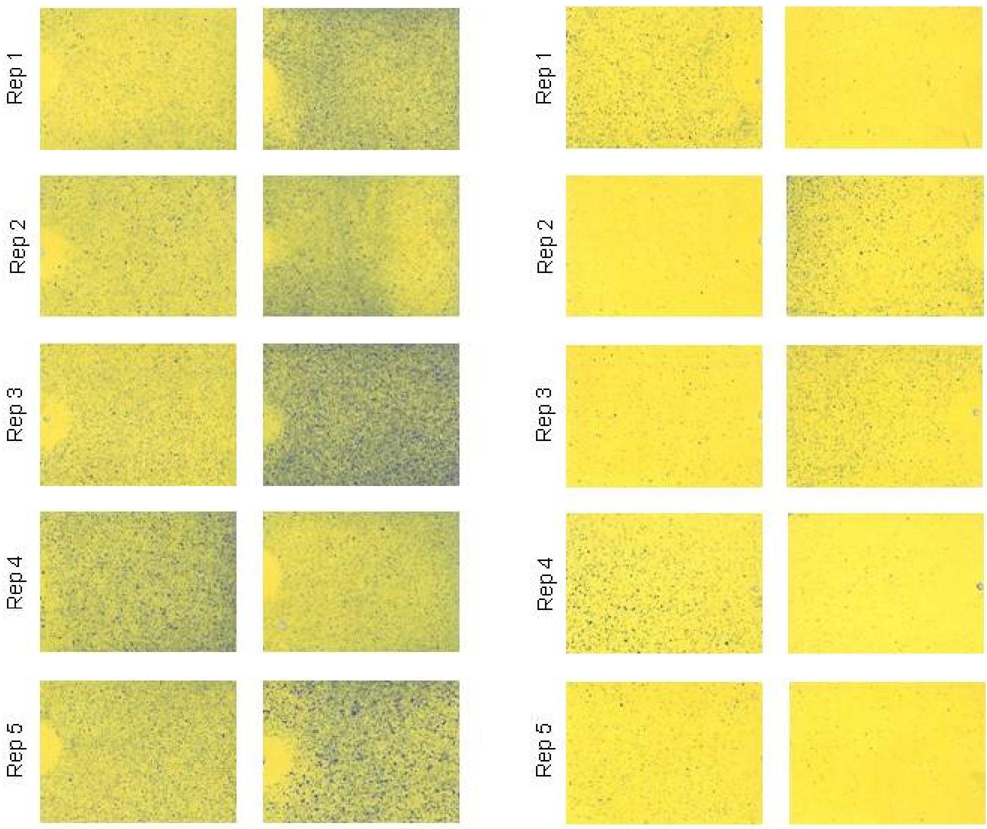


Trt: Electrostatic_run1_100ml/100L Du-wett (0.1%)

Leader lower canopy deposits — Upper surface / Lower surface

Leader upper canopy deposits — Upper surface / Lower surface



Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

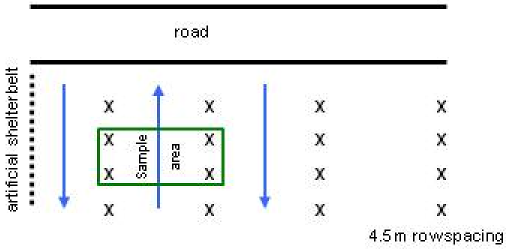
Date: 9th Dec 2011

Sprayer: ESS Electrostatic sprayer.
Forward & back angled nozzles ca. 0.8m below canopy.

Wind speed (m/s): 1 m/s (1.8 max)
Temperature: 25°

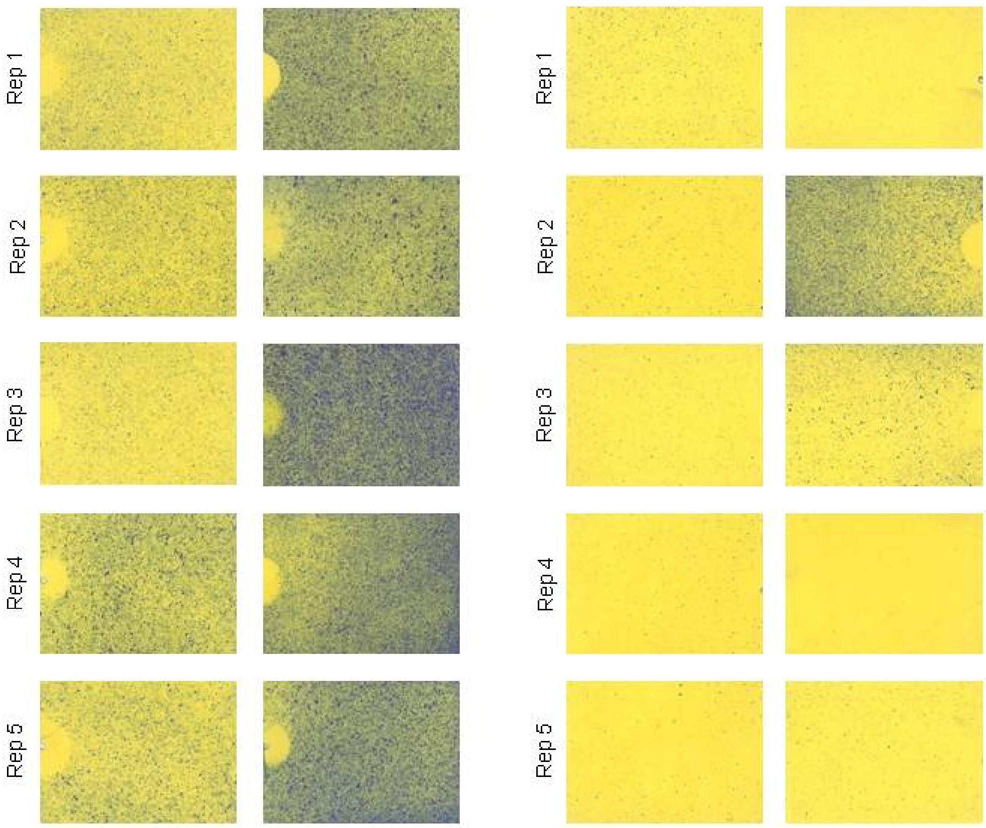
Nozzles: 28x ESS nozzles
Pressure:
Water rate (L/ha): 120L
Travel speed (km/h): 6.2 km/hr

Sprayer travel direction:



Trt: Electrostatic_run2_100ml/100L Du-wett (0.1%)

Centre lower canopy deposits		**Centre upper canopy deposits**	
Upper surface	Lower surface	Upper surface	Lower surface



Plant Protection Chemistry NEW ZEALAND

Sprayer comparisons_Trial2_Ground based sprays, on Hort 16A foliage canopy using water sensitive papers.

Location: Te Matai Rd, Te Puke.

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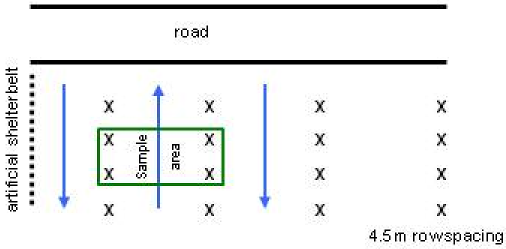
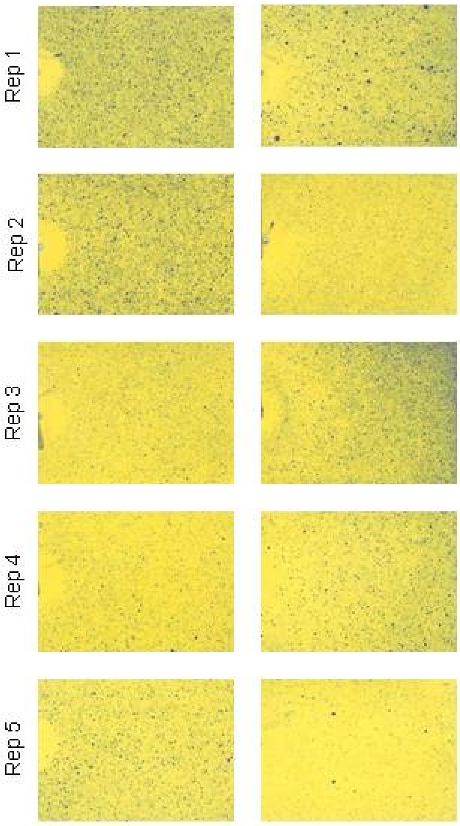
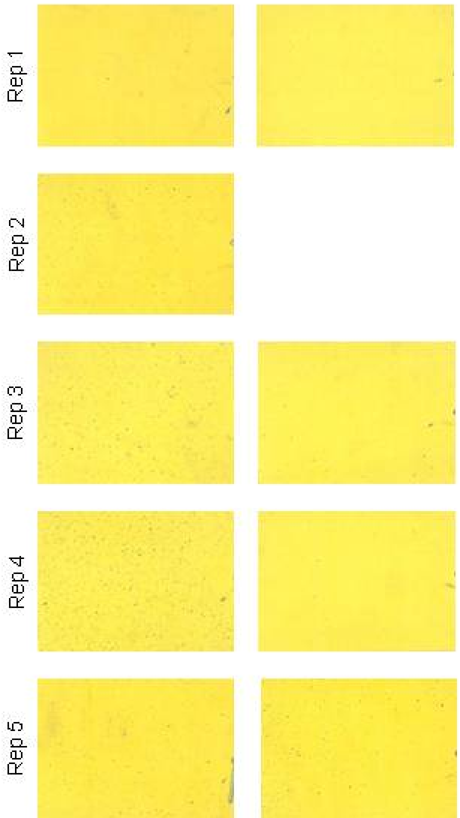


Trt: Electrostatic_run2_100ml/100L Du-wett (0.1%)

Leader lower canopy deposits
Upper surface   Lower surface



Leader upper canopy deposits
Upper surface   Lower surface



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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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