CROPLANDS

QUANTUM MIST™ CITRUS SPRAYER

TEST REPORT NUMBER 4:

Citrus tower:

Coverage/dose rating on citrus foliage

QUANTUM MIST™ CITRUS SPRAYER

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REPORT BY THE SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE:

Quantum Mist, citrus tower:

Coverage/dose testing on citrus foliage

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Croplands Equipment Pty Ltd

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Summary

Overall, excellent coverage and deposition was obtained with the Quantum Mist citrus tower sprayer on orange trees with dense foliage.

The spray volumes used were:

- 9 litres/Unit Canopy Row (UCR), (109 litres/100m, (1555 litres/ha))
- 12 litres/UCR, (207 L/100m, (3086 L/ha))
- 18 L/UCR, (281 litres/100m, (4007 L/ha))

These volumes are well below that normally used with oscillating boom and other high volume citrus sprayers 12 L/UCR, (200 litres/100m on a typical mature size tree (about 3000 litres/ha)) for nutrient spraying to 25-40 L/UCR, (400-700 litres/100m (about 6000-10 000 litres/ha)) for high volume spraying. The speeds used in the trials were 2.6, 4 and 7 km/h. The two higher speeds are substantially higher than current practice.

The coverage, wetness and dose obtained, especially on lower leaf surfaces, was similar to that obtained with current high volume citrus sprayers. It is likely that coverage would be superior to current high volume sprayers at spray volumes of 350 litres/100m (or greater) (about 4500 L/ha). We believe that the coverage and deposition obtained in this trial is likely to be adequate for good control of pests and diseases. The results also suggest that with higher pump capacities, ground speeds could be further increased without loss of coverage, but more work needs to be done.

These were un-replicated preliminary demonstration trials in a range of situations. More detailed trial work is therefore needed to confirm these findings. However, the results have been remarkably consistent in two separate orchards and several different situations. Commercial pest monitoring on one orchard also indicated good efficacy against a range of citrus pests, but data is not available. Efficacy work is also needed.

Pictured at left: Quantum Mist™ eight-head tower sprayer working in citrus.

Background

The multi-head spraying concept was initiated by SARDI a number of years ago. This concept combines the advantages of excellent coverage, high speed operation, high work rate, low power input, low labour input, flexibility and suitability for multiple row spraying with relatively small tractors, and the flexibility for both high and low volume spraying (Furness 2002 and 2003 (c)). These advantages have led to the current popularity of the Quantum Mist sprayer in grapevines and other crops. The concept is based on the theory that large volumes of low velocity air, direct blast, with no ducting or bending of the airstreams gives the best coverage with the lowest power inputs (Furness and Pinczewski 1985, Randall 1971).

A joint research and development project between SARDI, Orlando Wyndham and Simeon Wines during 2001 and 2002 on grapevines led to the development of a radically new design for an axial flow fan for these sprayers (Furness 2002, 2003 (c) and 2003(d)). The fan design work was carried out by Bolly Products and J Packer Design, which built on some initial concepts from Dr Alan Fein, formerly of the Department of Aeronautical Engineering at the University of Sydney (now retired). Croplands were selected as the commercial partner for the distribution of the new fan, which is now being fitted to all new Quantum Mist sprayers, including the sprayer used in this evaluation. This R&D work demonstrated the following advantages with the new SARDI fan in winegrapes:

- Spray coverage is maintained over a wide speed range, with good coverage up to 12 and even 15 km/h at 2800 rpm.
- At 2000 rpm the power requirement for the fan is about 1 kw and the air volume is about 12000 cu m/h, giving a total air volume per vine row for a 4 head sprayer of about 48000 cu m/h, which is ample for grapevine canopies.
- The fixed pitch design results in good airflow over the full length of the blade, especially close to the hub. Hence the fan does not produce an expanding “donut” or ring of air coming off the fan as with the older Titan fans, but rather a full solid cone of air with no expanding reverse airflow region in the centre of the swath. This type of airflow also reacts better against the back pressure created by the canopy, giving improved air penetration into the canopy (Furness et al 2003 (d)). It also allows more flexibility in the direction the nozzles can be angled. In addition it also helps keep moisture off the drive motor and bearings.
- One-piece design also means that it is quick and easy to fit and remove the fan from the hub, and the simpler hub is also easy to fit and remove from the drive shaft of the motor.

In test report number 1 (Furness 2004), fan rotational speed, head placement and nozzle angling was evaluated for large sprawl grapevine canopies. The optimal fan rotational speed was 2000 rpm, but similar coverage was found from 1750 rpm to 2600 rpm. Coverage started to fall at 1500 rpm. Fan rotational speed may need to be a little higher in citrus due to the larger canopy. In test report number 2 (Furness 2005), the effects of head placement on coverage and deposition was studied on VSP grapevine canopies. Nozzle angling was also set up the same for this study.

The aim of this study was to provide initial data on spray coverage and deposition on citrus foliage, at a medium spray volume, to determine the potential for Quantum Mist technology for spray application to citrus and other fruit tree crops.

Methods

Sprayer set up, conditions and treatments

Two separate Quantum Mist Tower, citrus sprayers were evaluated:

1. PETER WALKER, SUNLANDS, SA
A double side unit with 8 heads was fitted with 8 Spraying Systems TX VK 12 (brown) hollow cone, ceramic tipped nozzles per head giving a spray volume of 207 litres/100 m (Furness et al 1998, Furness 1998). The pressure was 11 bar at the pump and 10 bar at the nozzles. Travel speed was 2.6 km/h.
Flow rate per jet: 1.40 litres/min/jet.
Total flow rate: 11.2 litres/min/head, 89.6 litres/min/row (8 heads)
Actual spray volume:
12.9 Litres/UCR, 207 litres/100m (per row) (3086 litres/ha)

2. RODNEY HAND, COLIGNAN, VIC

A double side unit with 8 heads was fitted with 10 Spraying Systems TX VK 8 (grey) and 6 Spraying Systems TX VK 18 (orange) hollow cone, ceramic tipped nozzles per head. Two spray volume/travel speed combinations were used:

- 9 Litres/UCR (approx.), 109 Litres/100 m (1555 Litres/ha), 7 km/h, 63.5 L/min/4 heads at 9.5 bar pressure at the nozzle.
- 18 Litres/UCR (approx.), 281 L/100 m (4007 L/ha), 4 km/h, 93.5 L/min/4 heads at 15 bar pressure at the nozzle.

TREATMENTS

The position of the spray heads relative to the canopy is shown in the photographs. SARDI Yellow Fluorescent Pigment, at a concentration of 1 litre/100 litres was added to the spray vat. A block of 3 rows x 7 trees per row was sprayed from both sides with sampling from 1 tree in the centre of the middle row at Peter Walker's orchard and 2 trees in the centre of the middle row at Rodney Hand's orchard.

Orchard and conditions

1. WALKER, SUNLANDS

The trial was carried out on 3 December 2004 on Peter Walker's orchard at Sunlands near Waikerie on medium size Washington Navel orange trees.

- Row spacing: 6.7 m
- Tree height 4.4m
- Canopy height: 3.9 m
- Maximum canopy width: 4.6 m
- Average canopy width: 4.1 m

Foliage was dense, with a light and variable crop of small to medium sized fruitlets. Row direction N-S. Sprayer travel direction was S to N on west side of trees and N-S on east side of trees.

Conditions: Fine and sunny, 23 deg C, medium humidity, wind light (0-5 km/h) from SW.

2. HAND, COLIGNAN

The trial was carried out on 3 June 2005 on Rodney Hand's orchard at Colignan, Victoria on medium sized Valencia orange trees.

- Row spacing: 7 m
- Tree height 3.8 m and 3.3 m approx. (281 litre treatment, 109 litre treatment resp)
- Maximum canopy width: 4.5 m and 4 m approx. (as above)
- Average canopy width: 4 m and 3.5 m approx. (as above)

Foliage was dense, with a mature crop of moderate to high fruit density present, such that the trees were at their most difficult stage for achieving good coverage.

Row direction N-S. Sprayer travel direction was S-N on west side of trees and N-S on east side of trees.

Conditions: Fine and sunny, 14 deg C, high humidity, calm.

Sampling and assessment

The trees were divided into 14 strata at Peter Walker's orchard and 26 strata at Rodney Hand's orchard. The following numbers of leaves were picked from each strata:

- Centre area of the tree, top half – 20 leaves (Walker's) or 10 leaves (Hand's) sampled
- Centre area of the tree, bottom half – 20 leaves (Walker's) or 10 leaves (Hand's) sampled
- 0.5 – 1.8 m high, outer canopy – 15 leaves (Walker's) or 10 leaves (Hand's) sampled
- 1.8 – 3.1 m high, outer canopy – 15 or 10 leaves sampled as before
- 3.1 – 4.4 m high, outer canopy – 15 or 10 leaves sampled as before
- 0.5 – 1.8, 1.8 – 3.1 and 3.1 – 4.4 m high, inner canopy – 15 or 10 leaves sampled at each level as before
- Sampling was repeated for east and west sides of the tree at Walkers and north east, south east, north west and south west at Hand's, not including the two centre of tree sites.

In addition, at Walker's, fruitlets were sampled from the outer canopy, bottom, middle and top. East and West aspects were combined. Samples were also taken from the centre area of the tree. The number sampled was small and variable because the crop was very light and variable across the canopy. At Hand's, 5 fruit was sampled from the mid height of the tree at all four aspects from the outer canopy only.

Leaves and fruit were assessed under black light illumination in a darkroom for the numbers of fine droplets per square cm using the standard visual rating chart technique of Furness 2000. Four ratings from highest to lowest were made on each leaf surface and for each fruit surface. The fruit sampled from Hand's was only rated for the proportion of the fruit surface and the calyx area that was wet.

Standard citrus sprayers and hand spraying

For comparison, results at high volume rates are presented for two oscillating boom sprayers and an airblast sprayer fitted with an overhead hydraulic nozzle boom. Results are also presented for the standard hand wand spraying technique and the red scale hand wand spraying technique. The methods and sampling used were similar to that used with the two Quantum Mist sprayers.

Results and discussion

Coverage

In figures 1-9 the number of droplets per cm^2 and the dose deposited, are plotted as fine spots in the 14 sites on a diagrammatic cross section of a citrus tree and on a diagram of a citrus fruit and a fruit calyx. In each site, the mean of the 4 ratings from the mean maximum to the mean minimum is plotted with rating 1 outermost to rating 4 innermost.

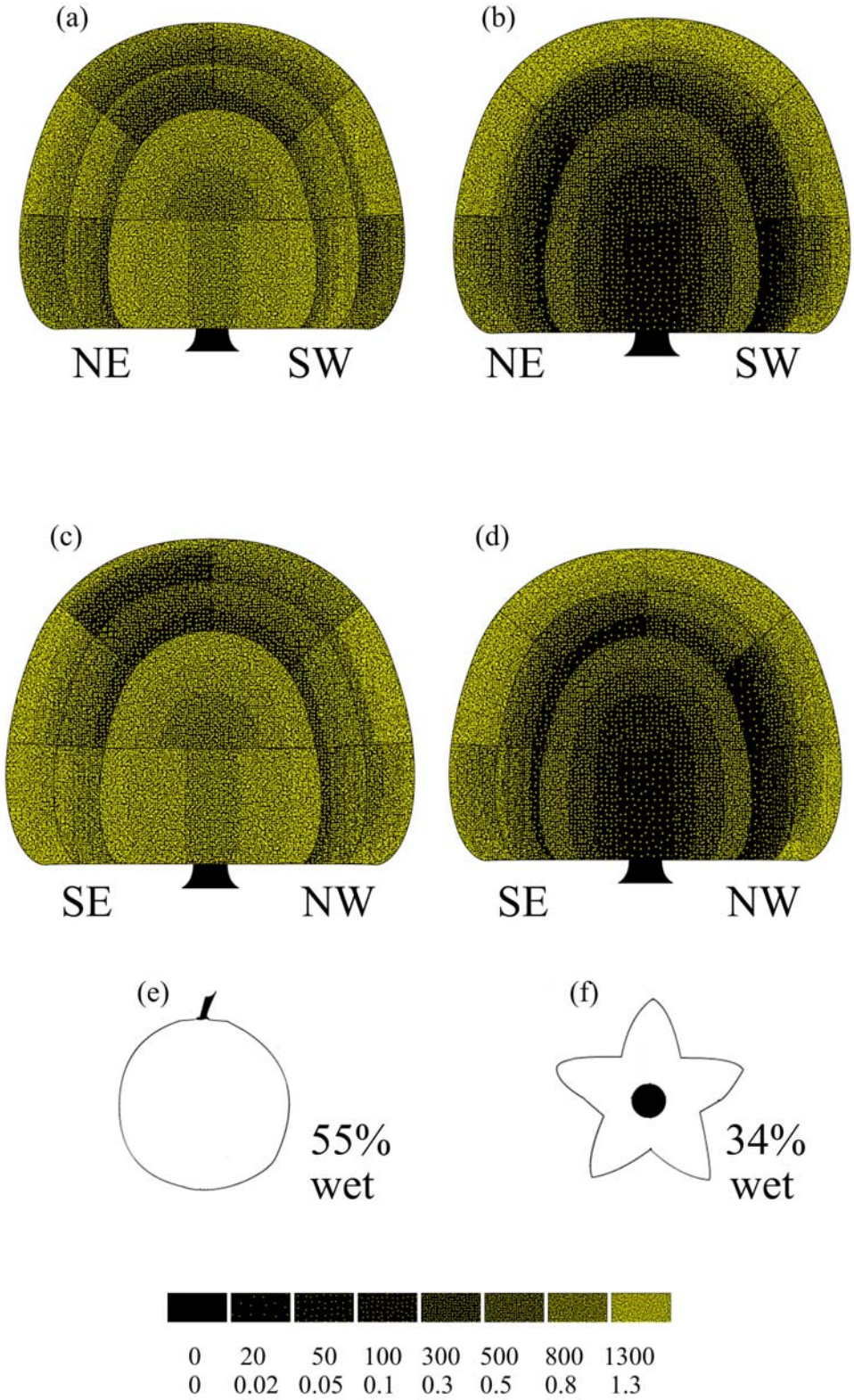

Figure 1. Droplet deposition on citrus trees using a Quantum Mist citrus tower sprayer with a spray volume of 18 L/UCR (281 L/100 m, 4000 L/ha) and a spraying speed of 4 km/h in a dense Valencia orange canopy with a medium to dense mature crop. (a),(c) upper leaf surface; (b),(d) lower leaf surface; (e) fruit surface; (f) fruit calyx. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

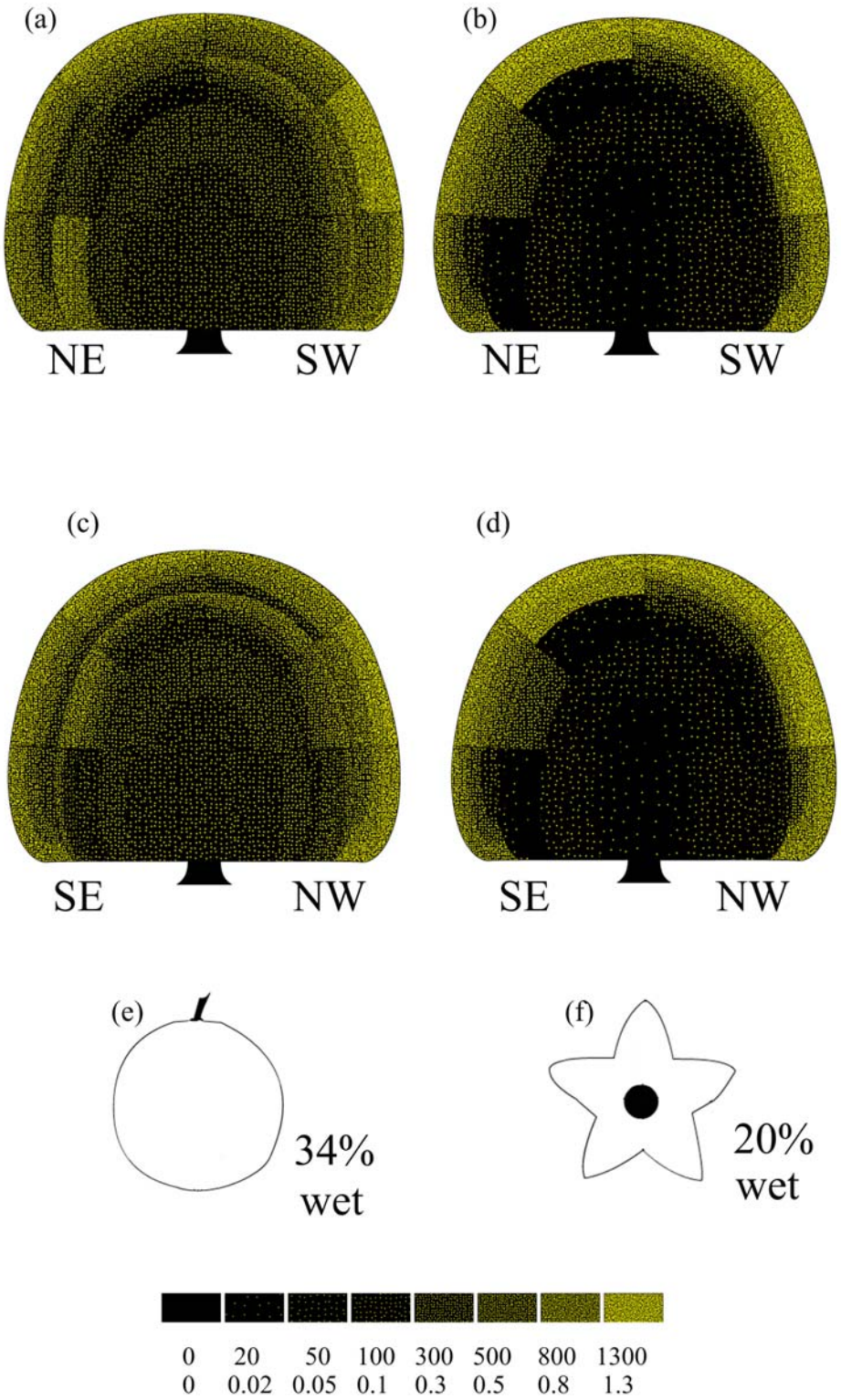

Figure 2. Droplet deposition on citrus trees using a Quantum Mist citrus tower sprayer with a spray volume of 9 L/UCR (109 L/100 m, 1555 L/ha) and a spraying speed of 7 km/h in a dense Valencia orange canopy with a medium to dense mature crop. (a),(c) upper leaf surface; (b),(d) lower leaf surface; (e) fruit surface; (f) fruit calyx. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

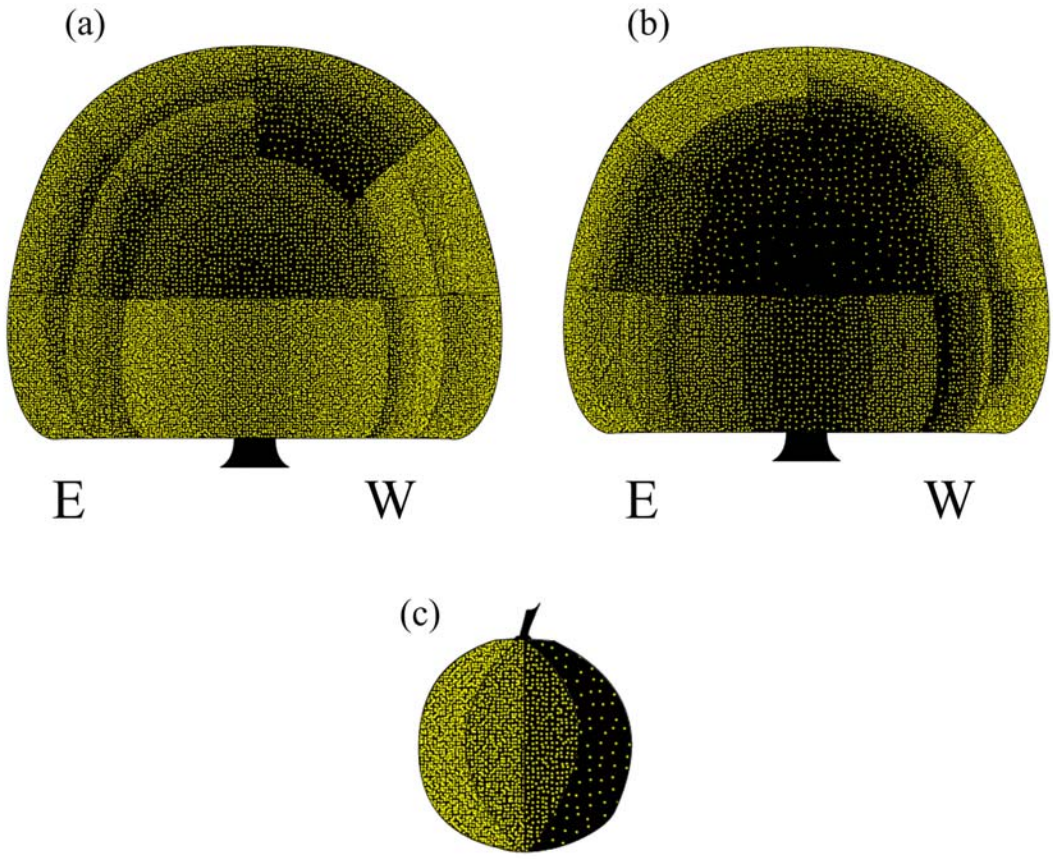

Figure 3. Droplet deposition on citrus trees using a Quantum Mist citrus tower sprayer with a spray volume of 12.9 L/UCR (207 L/100 m, 3086 L/ha) and a spraying speed of 2.6 km/h in a dense navel orange canopy with a sparse crop of small immature fruit. (a) upper leaf surface; (b) lower leaf surface; (c) fruit surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

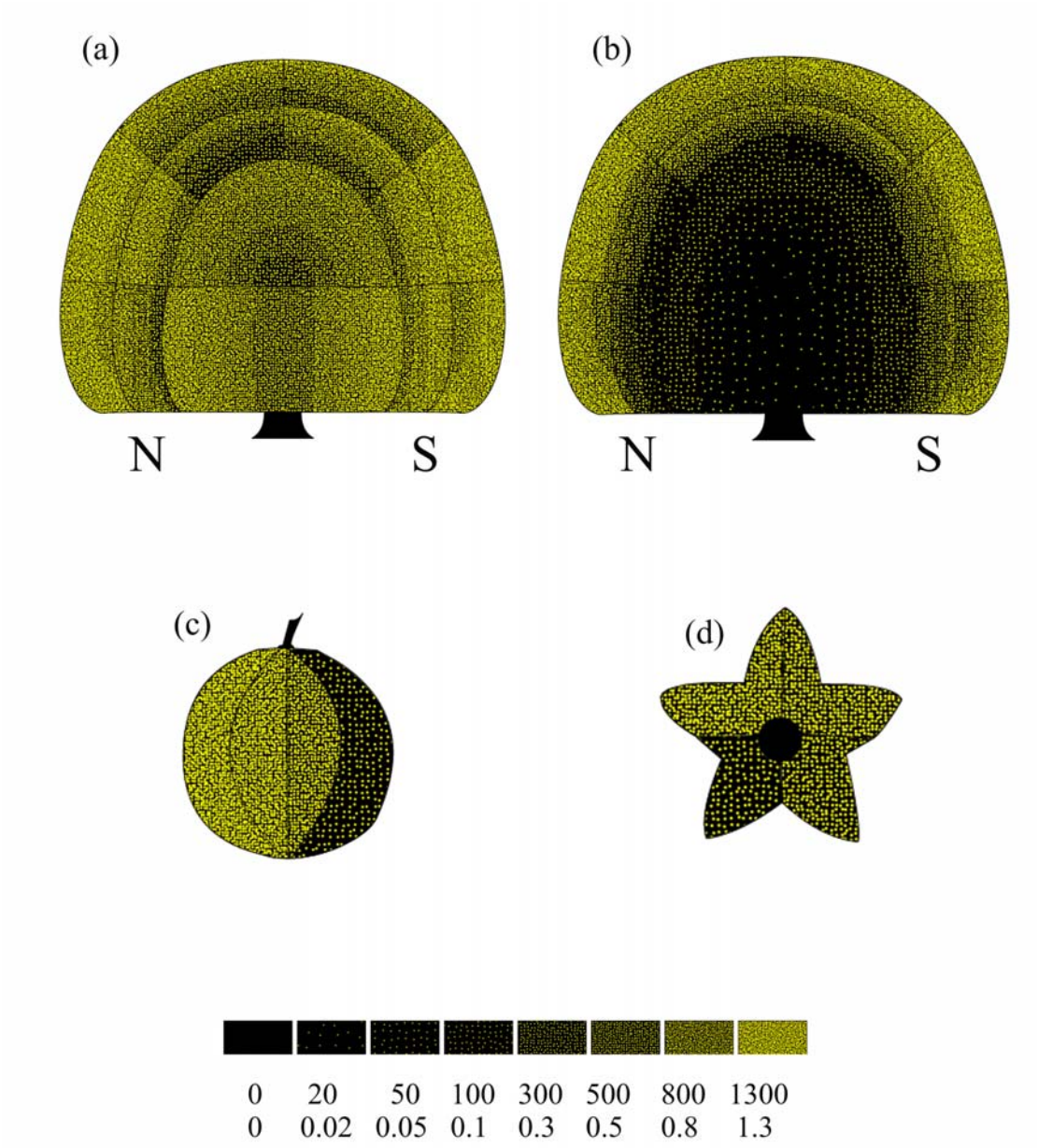

Figure 4. Droplet deposition on citrus trees using an oscillating boom sprayer with a spray volume of 30 L/UCR (729 L/100 m, 9900 L/ha) and a spraying speed of 2.8 km/h in a large dense navel orange canopy with a medium crop of small to medium sized immature fruit. (a) upper leaf surface; (b) lower leaf surface; (c) fruit surface; (d) fruit calyx. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

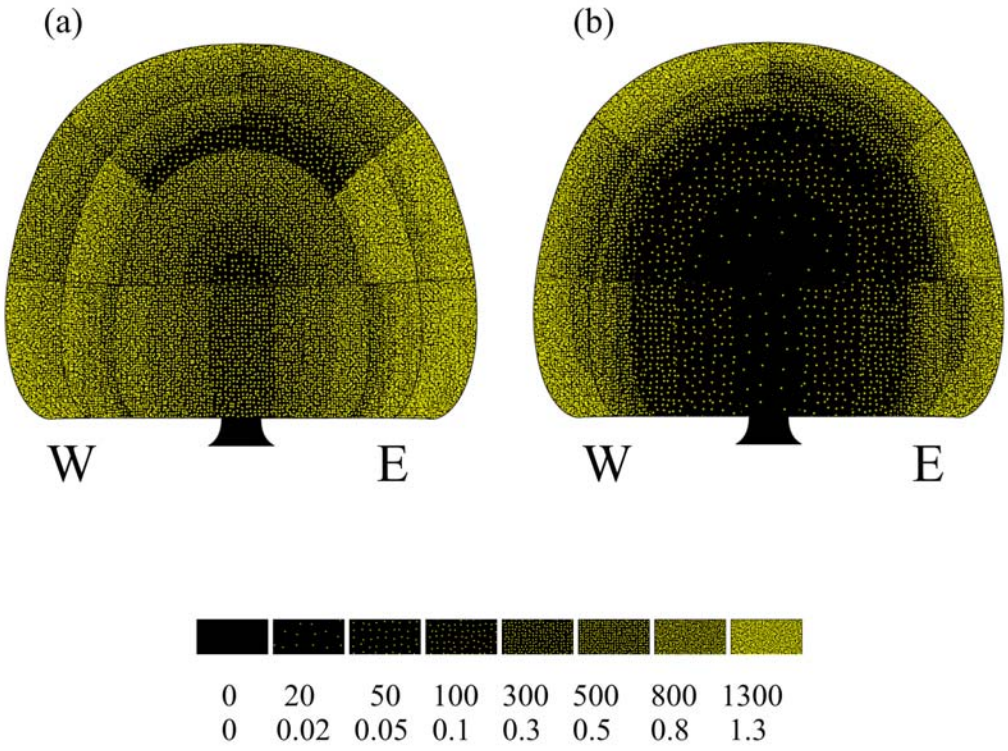

Figure 5. Droplet deposition on citrus trees using an oscillating boom sprayer with a spray volume of 26 L/UCR (323 L/100 m, 4800 L/ha) and a spraying speed of 3.7 km/h in a sparse navel orange canopy with almost no fruit (medium to large). (a) upper leaf surface; (b) lower leaf surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

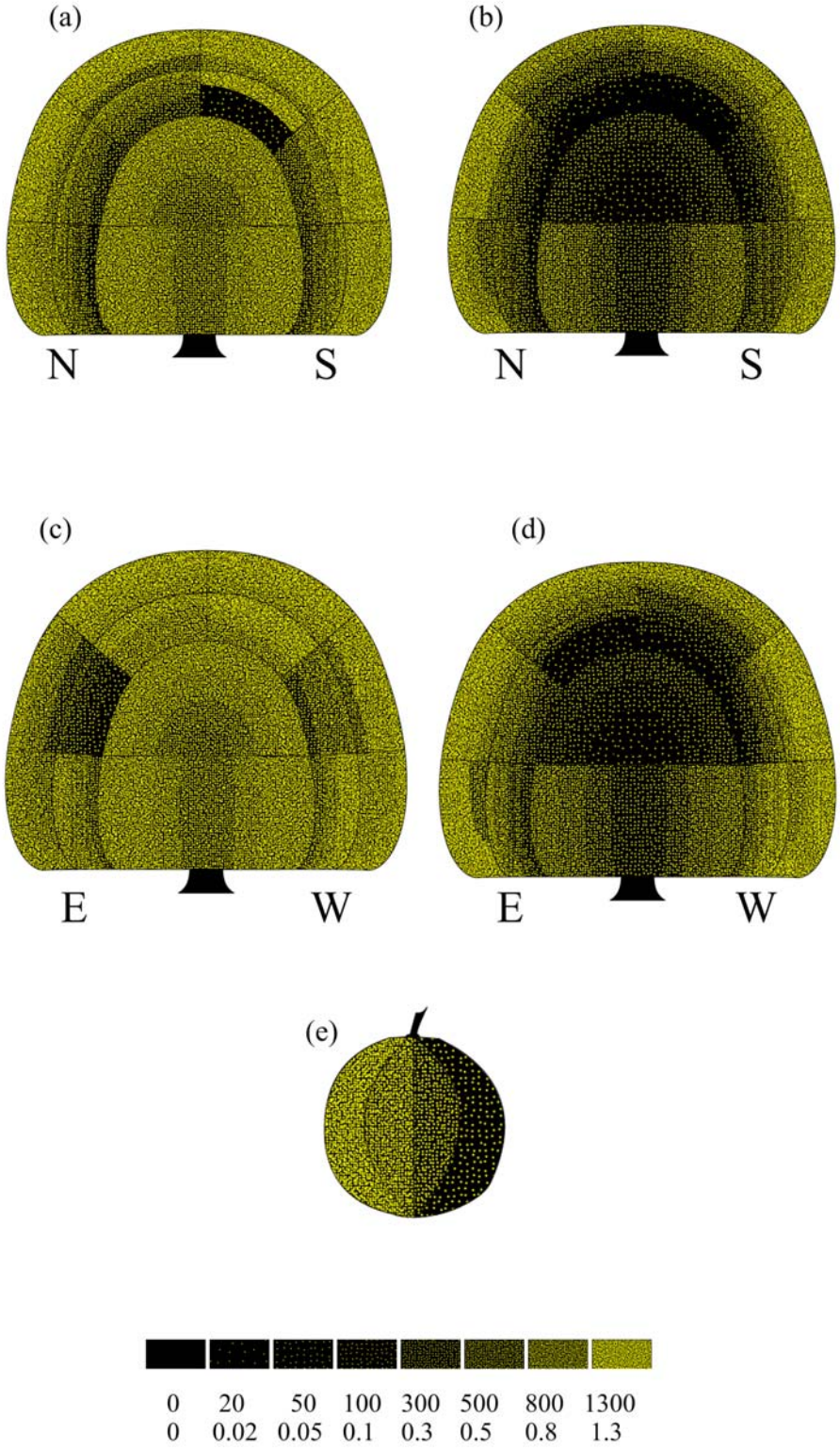

Figure 6. Droplet deposition on citrus trees using an airblast sprayer fitted with a hydraulic nozzle tower using a spray volume of 16 L/UCR (476 L/100 m, 7200 L/ha) and a spraying speed of 2.7 km/h in a sparse (sides of tree where hedged)) to dense (between trees) large navel orange canopy with a dense crop of small fruit. (a),(c) upper leaf surface; (b),(d) lower leaf surface; (e) fruit surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

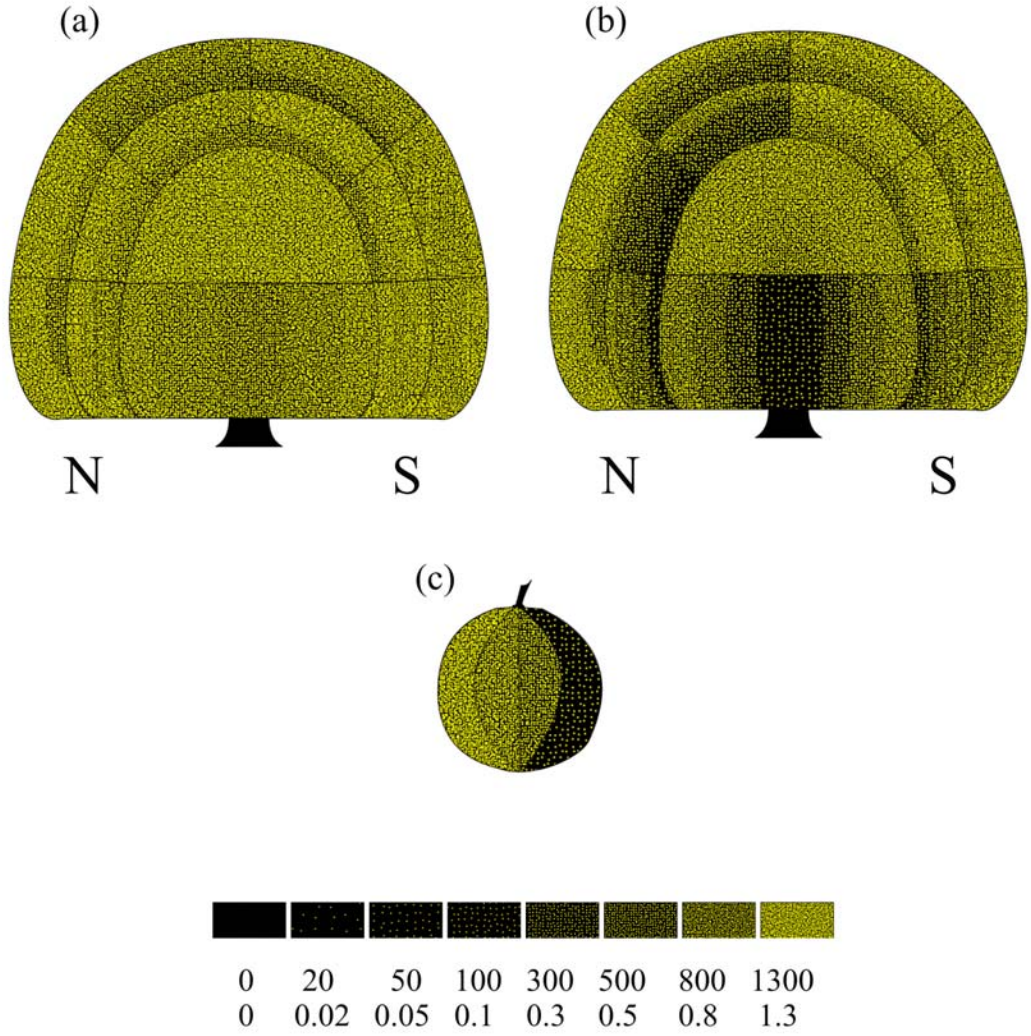

Figure 7. Droplet deposition on citrus trees using the red scale hand-wand spraying technique to apply a spray volume of 64 L/UCR (429 L/100 m, 5700 L/ha) to a small dense navel orange canopies with small immature fruit. (a) Upper leaf surface; (b) lower leaf surface; (c) fruit surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

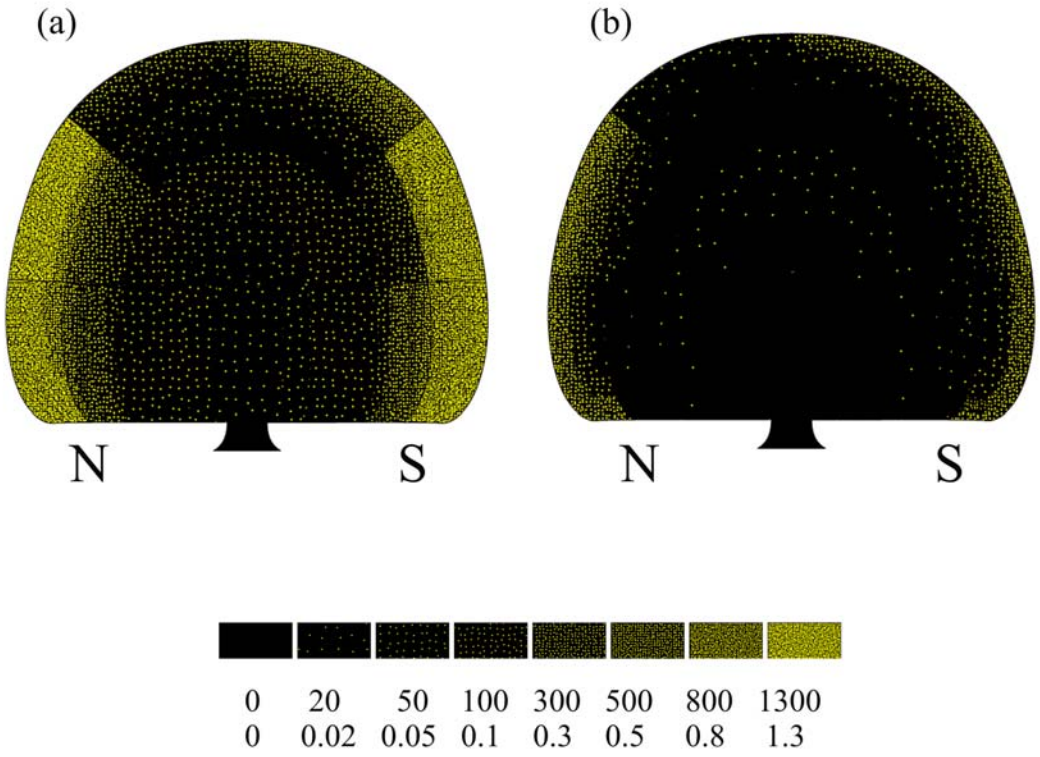

Figure 8. Droplet deposition on citrus trees using the standard hand wand spraying technique to apply a spray volume of 27 L/UCR (188 L/100 m, 2600 L/ha) to a small dense navel orange tree canopy with small immature fruit. (a) Upper leaf surface; (b) lower leaf surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

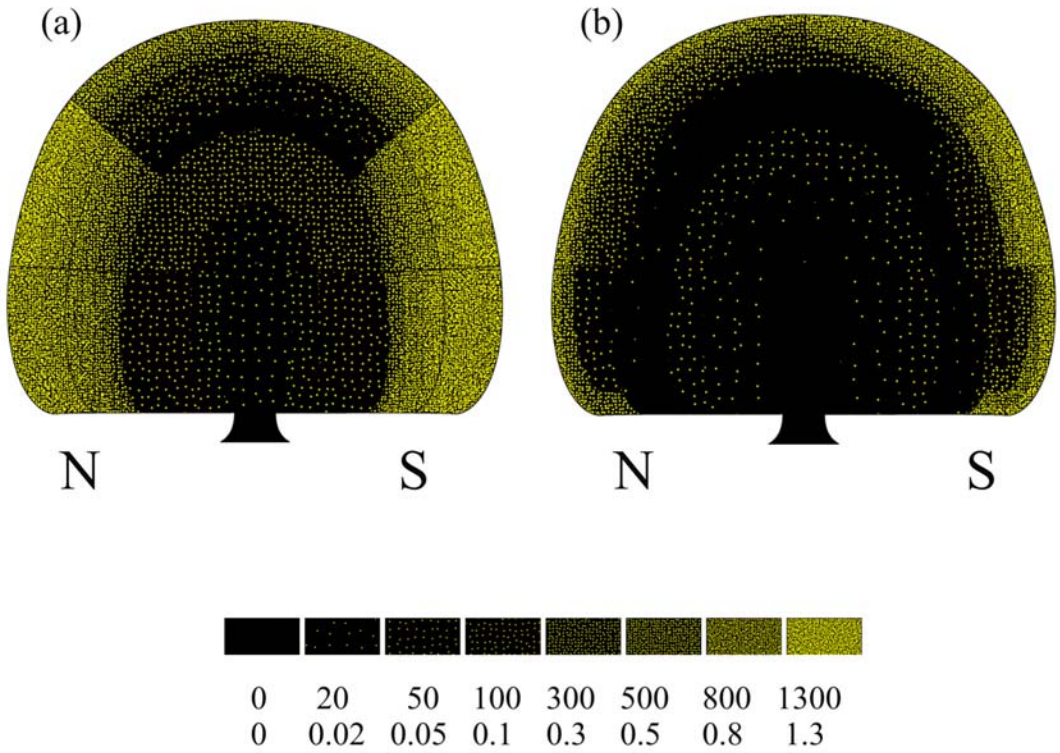

Figure 9. Droplet deposition on citrus trees using the standard hand wand spraying technique to apply a spray volume of 38 L/UCR (188 L/100 m, 2600 L/ha) to a small dense navel orange tree canopy with small immature fruit, (second run). (a) upper leaf surface; (b) lower leaf surface. Bar legend: upper scale – droplet number/cm^2; lower scale – microlitres/cm^2.

In figures 10-18 in the Appendix, the number of droplets per cm^2 on the y-axis is plotted against the canopy site from which the leaves came on the x-axis.

The Quantum Mist gave coverage, dose and wetness levels that were very similar to the standard oscillating boom sprayers and the airblast sprayer fitted with a hydraulic nozzle tower. However, the results were achieved using spray volumes for high volume application of 12.9 L/UCR (207 litres/100 m or 3086 litres/ha) and 18 L/UCR (281 L/100 m or 4007 L/ha) on medium sized trees with a dense canopy. These volumes are substantially lower than that used with standard high volume citrus spraying (25-40 L/UCR, 400-700 L/100m, 6000-10000L/ha). The 18 L/UCR spray at Hand's orchard was done at a travel speed 4 km/h, substantially higher that that used with the standard high volume citrus sprayers. These coverage levels should be adequate for good efficacy with oil spraying, hormone application and for difficult pests like mealybugs and light brown apple moth with insecticides. At 9 L/UCR (109 L/100 m or 1555 L/ha) at 7 km/h, coverage, dose and wetness was only slightly lower, ideal for most other insecticides, fungicides and nutrient sprays.

We suggest that at 20 L/UCR (350 L/100 m, 4500 L/ha) or higher, coverage, dose and wetness is likely to exceed what can be achieved with the standard high volume citrus sprayers.

Deposition patterns suggested that the Quantum Mist is a little better than the standard sprayers for depositing spray on lower leaf surfaces and in the centre area of the tree while the standard high volume sprayers are a little better on the upper leaf surfaces, especially in the outer canopy.

With hand wand spraying, as expected, the best coverage, dose and wetness was achieved with the red scale hand wand spraying technique. However, the standard hand wand spraying technique gave very poor coverage, dose and wetness, especially on the lower leaf surfaces, in the centre area of the tree, and in the tops of the trees. On the basis of these results, we suggest that the agricultural chemical industry should use the red scale technique when carrying out efficacy trials to determine pesticide label rates for citrus, especially with hormone sprays.

Coverage was only slightly reduced at 9 L/UCR, (109 L/100 m, 1555 L/ha) using a travel speed of 7 km/h. Observation also showed that the spray cloud travelled about 4 rows against a light breeze Both these factors suggest that excellent coverage and deposition will be maintained at substantially higher travel speeds than normally used in high volume citrus spraying. Hence it is suggested that work be carried out at approximately 7 km/h using 12-18 L/UCR (200-300 L/100m, 3000- 4000 L/ha). This would require a greater pump capacity.

Calculating impacted agricultural chemical dose (Furness 2000, Furness 2004, Furness 2005)

Dividing the droplet number/cm^2 by 1000 (for fine droplets) gives the spray volume impacted on the foliage in microlitres/cm^2.

Amount of chemical deposited (microlitres or micrograms/cm^2) =
Microlitres impacted/cm^2 x amount of chemical (litres or grams)/100 litres ÷ 100

The amount of active ingredient deposited =
Amount of chemical deposited x % active ingredient ÷ 100

Analysis of the results

These were preliminary demonstration trials only. Further work is therefore required before any significant claims can be made. The lack of proper trial design and replication means that the results can't be analysed. However, work with the Quantum Mist was repeated on two orchards at two different application times, and there was good consistency in the results. This suggests that similar results in replicated trials will be obtained.

Acknowledgements

The support of Andrew Thompson, Craig Solly, staff from Croplands Equipment Pty Ltd, Walker Citrus, especially the manager, Peter Walker, and Reg Willis, and Rodney Hand and staff in applying the treatments, setting up, operating the equipment and helping with sampling is gratefully acknowledged. We also thank Croplands Equipment Pty Ltd for supplying the Quantum Mist Citrus Tower at Rodney Hand's orchard, and Croplands Equipment Pty Ltd and Hall Engineering for rebuilding the original Walker Auspray into a Quantum Mist sprayer. The efforts of Matthew Palmer and Andrew Thompson in plotting the diagrams are also gratefully acknowledged.

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