

CROPLANDS

QUANTUM MIST™ GRAPE SPRAYER



TEST REPORT:

OPTIMISING SET UP AND OPERATION:

**FAN ROTATIONAL SPEED, HEAD PLACEMENT AND
NOZZLE ANGLING FOR LARGE SPRAWL CANOPIES**

QUANTUM MIST™ GRAPE SPRAYER

REPORT BY THE SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT
INSTITUTE:

OPTIMISING SET UP AND OPERATION:

EFFECT OF FAN ROTATIONAL SPEED, HEAD PLACEMENT AND NOZZLE ANGLING ON SPRAY DISTRIBUTION IN LARGE SPRAWL GRAPEVINE CANOPIES

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Report produced for
Croplands Equipment Pty Ltd



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Summary

Fan Speed

- The optimum fan rotational speed was 2000 rpm (at a travel speed of 7.0 km/h on a medium to large late season, sprawl type Cabernet Sauvignon canopy grown on a two wire vertical trellis sprayed in late January in a moderate wind).
- At 1750 rpm coverage uniformity was slightly less, and it was marginally less at 2600 rpm. Overall, at 1750 rpm or higher the coverage was remarkably even throughout all sites in the canopy, including sheltered inner sites and lower leaf surfaces. At 1500 rpm there was a more substantial drop in coverage.
- On upper leaf surfaces the coverage was similar at all rotational speeds, almost all of the drop in coverage at fan rotational speeds above and below 2000 rpm occurred on the lower leaf surfaces, particularly in the inner canopy.
- When the amount of sulphur that would be deposited was calculated, the results indicate that excellent control of pests and diseases could be expected at 1750 rpm or above, provided spray timing and frequency is correct, and dosing, through the use of correct calibration, is also correct (based on distance, and the size and density of the canopy, see the Croplands/SARDI Distance Based Calibration booklet, Furness 2003 (a), also Furness 2003 (b)).
- Analysis of the results is not complete. We believe it is likely that this will show that coverage at 1500 rpm is significantly poorer than the other treatments. There may also be a difference at 1750 rpm but this is uncertain until the analysis is complete. It is less likely that there will be any significant difference between 2000 and 2600 rpm.

Efficacy

- For concentrate spraying with sulphur (contact acting only), the maximum concentration factor recommended by chemical companies for concentrate spraying is 3. It is important to note that with the canopy size used in this trial, 20 litres per 100 m (equivalent to 670 litres per ha) is therefore about the minimum spray volume for good efficacy at full canopy. For larger canopies the minimum recommended spray volume is even higher.
- For some other chemicals, such as the DMI fungicides, higher concentrations and lower spray volumes could be used.

Spray head configuration

- Head placement and angling is important (see photograph).



Photo shows preferred placement and angling of

- Previous work has shown that maximising the convergence angles gives best results in sprawl canopies.
- Aim the top head about 45 degrees downwards through the top of the canopy, aimed at or slightly below the bottom wire. Aim the lower head about 45 degrees upwards from underneath the canopy, aimed at or slightly above the top wire and as close as practical to the trunk of the vines (the closest point of the shroud should typically be about 400 mm from the trunks and trellis posts).
- The top head should be vertically above the bottom head, with both heads at the same distance above and below the centre (vertical plane) of the canopy, with the two airstreams converging directly at each other at a point halfway between the centre of the canopy and the outside of the canopy in the sprayed row. Angle both heads slightly rearwards at about 10 degrees.
- Maximising the convergence angle increases turbulence and decreases leaf and foliage shingling, thereby improving spray penetration to the inner canopy, and lower leaf surfaces and bunches. It also greatly decreases the amount of spray going off target onto to the ground and vertically upwards as spray drift.



Photo shows heads set in sprawling canopy

Nozzle set-up

- The nozzles were operated at 8 bar pressure (about 9 bar at the pump). Observations of spray droplets on leaves indicated that the droplet size was slightly large for optimal coverage.
- Based on previous studies of this type, coverage uniformity, especially coverage on lower leaf surfaces and on inner canopy sites and bunches, would be further improved by operating at slightly higher nozzle pressure. (Consideration must however be given to the inherent increased spray drift that is likely to occur & other risks this may pose in terms of sprayer capabilities).
- With the SARDI fan, every second nozzle in each pair of 4 around the shroud was aimed across the face of the fan with the other nozzles aimed forwards but with a slight inward incline. (This could not be done with the older Titan fans because droplets from the nozzles aimed across the fan largely ended up in the reverse flow region in the centre of the “donut” of air and were drawn back towards the fan and some back through the fan close to the hub).

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 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 sprayers used in this evaluation. This R&D work demonstrated the following advantages with the new SARDI fan:

- 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 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 more than ample for grapevine canopies.
- The fixed pitch design results in superior 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. 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. It is also essentially corrosion resistant.



Geoff Furness with air speed metre

The aim of this study was to provide data on the effect of fan rotational speed, head placement and nozzle angling on spray coverage. This information can be used to optimise the set up of the Quantum Mist sprayer for spraying large sprawl grapevine canopies. It also builds on the independent test report on the Quantum Mist sprayer by Manktelow and MacGregor, May 2001, which was carried out on various VSP style canopies.

Methods

Sprayers and set up

Two sprayers were used. The first was a double row unit with 8 heads, the second a single row unit with 4 heads. Both were fitted with 4 Spraying Systems TX VK 8 (grey) and 4 SS TX VK 6 (red) hollow cone, ceramic tipped nozzles per head. The pressure was 8 bar at the nozzles. Travel speed was 7.0 km/h.

The positions of the heads relative to the canopy and the angling of the nozzles is described in the summary. The pictures also show the positions of the heads relative to the canopy. For comparison, a single rep was also sprayed at 2000 rpm with the heads set closer to the canopy than normal (shroud 200 mm from the trellis posts and vine trunks).



Vineyard and conditions

The trial was carried out on 22 January 2004 on the McGuigan Simeon Coldridge Vineyard near Loxton on a block of Cabernet Sauvignon. Foliage was medium density, minimal pruned, 2 wire vertical trellis, with a medium crop. The canopy had been lightly tipped. Conditions were fine sunny and hot with a temperature of about 35 deg C. The wind was moderate from the south at about 3 – 8 m/s.

- Row spacing: 2.75 m
- Canopy height: 1.2 m
- Canopy width: 1.5 m

Treatments

SARDI Yellow Fluorescent Pigment, at a concentration of 1 litre/100 litres was added to the spray vat. The following randomised treatments were applied to one row in each of two replicates with sampling from three two vine plots per treatment row in each rep. There was a sprayed buffer row each side of the treatment row (same treatment applied):

- Fan rotational speed 1500 rpm, two row sprayer
- Fan rotational speed 1750 rpm, two row sprayer
- Fan rotational speed 2000 rpm, two row sprayer
- Fan rotational speed 2600 rpm, single row sprayer
- Fan rotational speed 2000 rpm, two row sprayer with heads closer to the canopy.

The fans on opposite sides of the canopy with the two row sprayer were off set so that air stream interaction from opposite sides was small. Hence results with the single and double row sprayers should be similar. In addition, previous work comparing coverage with heads both sides of the canopy to coverage with a single row sprayer spraying two half rows at a time have showed only minor differences in coverage.

Sprayer set up parameters

- Travel speed 7.0 km/h
- Flow rate per jet: 0.840 litres/min for the grey jets and 0.615 litres/min for the red jets.
- Total flow rate: 23.28 litres/min/row
- Actual spray volume: 20.0 litres/100m (per row) (equivalent to 667 litres/ha, with 3 m row spacing)
- Required dilute spray volume: 54 litres/100m (per row)
- Concentration factor required = $54 \div 20 = 2.7$

Sampling and assessment

In each plot (total of 6 plots per treatment, 3 per rep), leaf samples were taken from 6 strata. Ten leaves were picked from:

- The outer upper canopy, both north and south sides separately
- The outer lower canopy, both north and south sides separately

15 leaves were picked from:

- The upper inner canopy
- The lower inner canopy

In addition, 10 bunches were picked from the upper canopy and 10 from the lower canopy.

Leaves and bunches 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 bunch surface.

Results and discussion

Effect of fan rpm on coverage and dose

The optimum fan speed for maximising deposition and coverage uniformity was 2000 rpm. The mean droplet numbers per cm² deposited on upper and lower leaf surfaces and on bunches in the various positions throughout the canopy are shown in figure 1. In table 1 the amounts of sulphur deposited in the 1500, 1750 and 2000 rpm treatments is estimated for the highest of the 4 ratings in the best sprayed site and the lowest of the 4 ratings in the worst sprayed site using the technique developed by Furness (2000).

1750 rpm gave coverage and deposition that was only slightly inferior to that at 2000 rpm. 2600 rpm was only marginally worse than 2000 rpm. It is not certain that these differences will be significant. However, there was a noticeable drop on coverage, coverage uniformity, and deposition at 1500 rpm. We believe it is likely that this difference will be significant.

The calculated doses of sulphur that would be deposited are very close in quantity and variability to that measured by Manktelow and MacGregor in their testing work on the Quantum mist. They also agree well with the extensive residue testing work on a wide range of sprayers by Murphy and Warren (unpublished data) in work funded by the Grape and Wine Research and Development Corporation. This suggests that estimating the amount of agricultural chemicals deposited from rapid visual assessment of droplet numbers deposited using fluorescent pigments is quite accurate and valid. It also indicates that further work on calibrating this rapid visual technique against chemical residue analysis work would be very valuable.

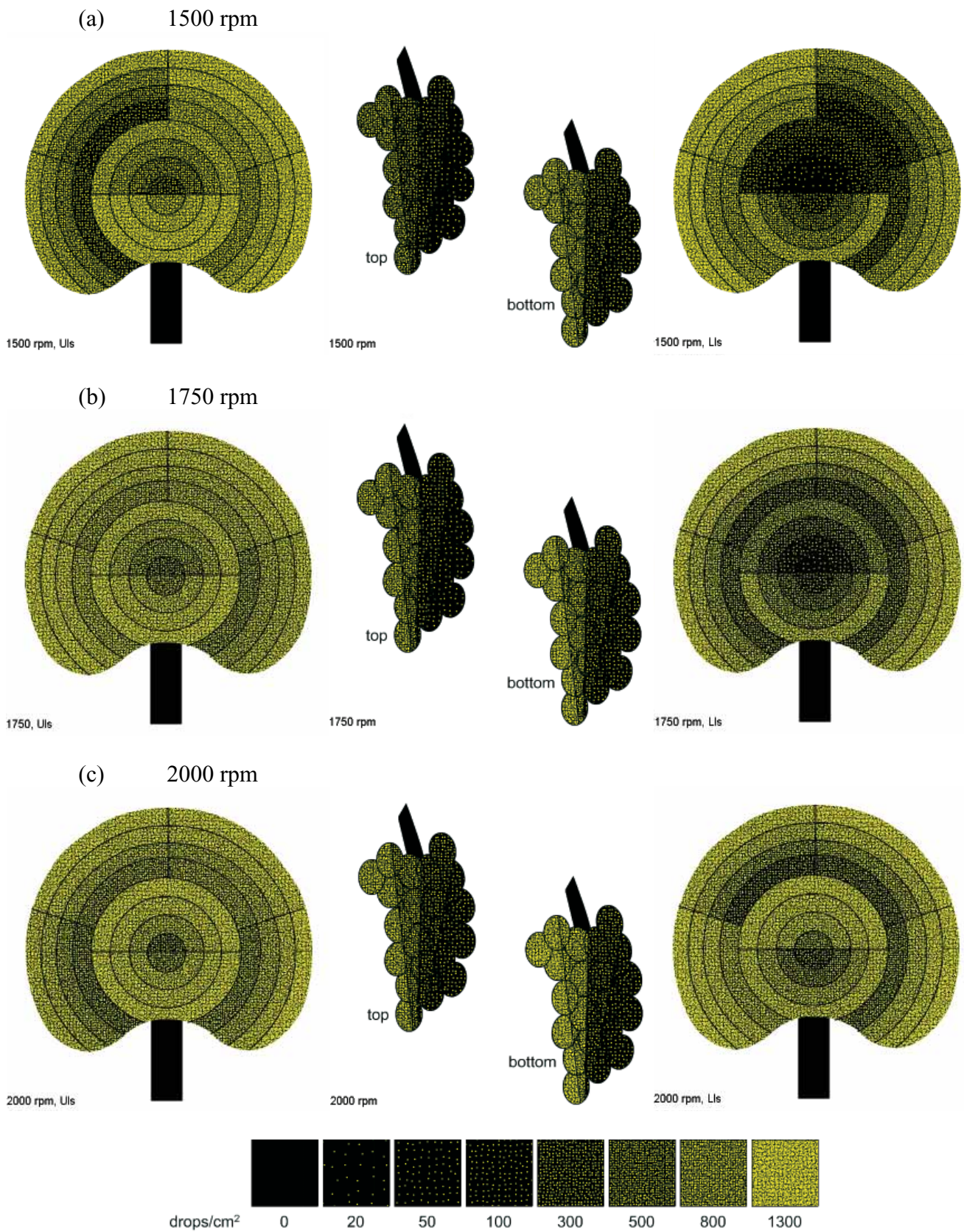
The work of Murphy and Warren established that deposition of 2.3 µg/cm² or better of sulphur is required for good efficacy against powdery mildew. This was achieved for all ratings in all leaf sites and most bunch sites at 2000 rpm, provided distance/canopy size calibration is used. It was also achieved at 1750 rpm on leaves in all but the lowest rating in the worst site and most of the bunch sites. Hence excellent control of pests and diseases can be expected at 1750 rpm or higher.

The work also highlights that sulphur deposition on large canopies with the old sulphur rate of 200 g/100 litres (2 kg/ha) (and also with the new label rates), using area based calibration, is not adequate for the control of powdery mildew. This was also established for all other sprayers by the work of Murphy and Warren. Chemical companies typically use 4 times the minimum effective dose when setting the label rate to allow for the inefficiencies of spraying (ie for sulphur a typical wetness deposit should contain about 8 to 10 µg/cm²). Hence the dose that would be obtained using distance/canopy size calibration is about right.

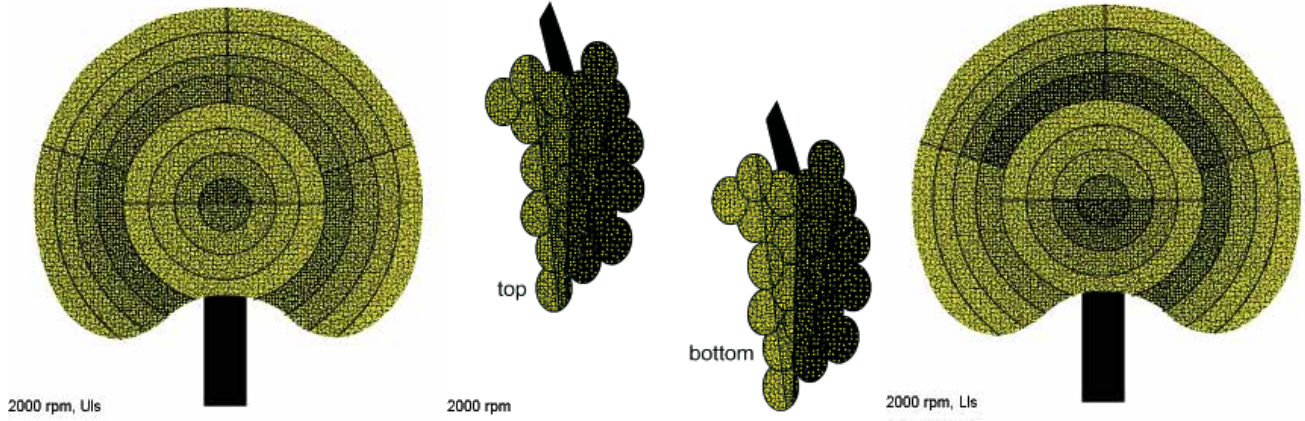
Head placement, pressure and droplet size, and nozzle angling

A full description of all of these parameters, and their importance and effects is given above in the summary.

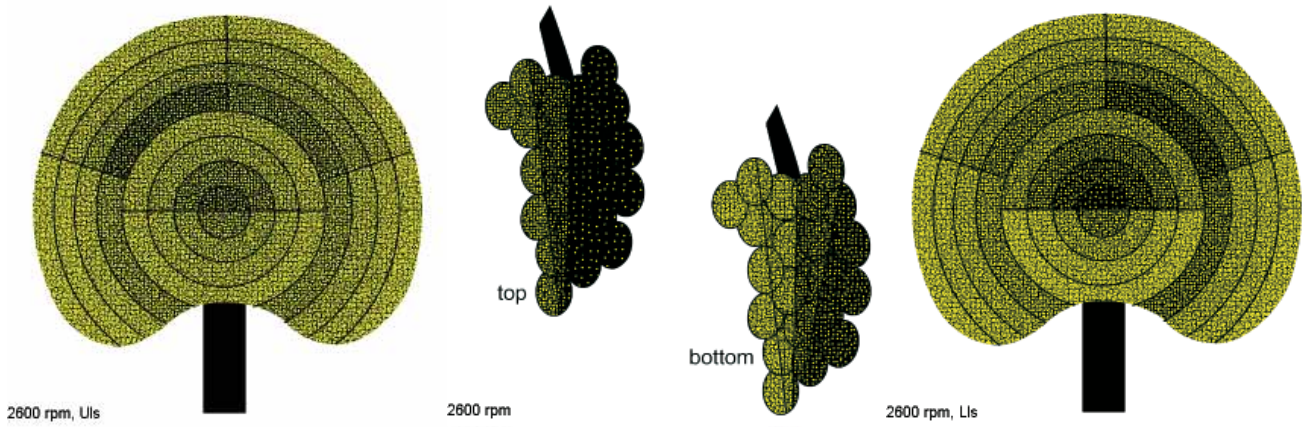
Figure 1. The effect of fan rotational speed on droplet deposition and dose in a moderate to large sprawl grapevine canopy



2000 rpm (repeated)



(d) 2600 rpm



(e) 2000 rpm, heads very close to the vine

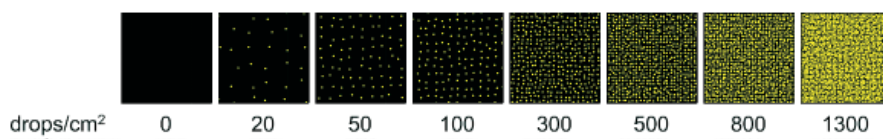
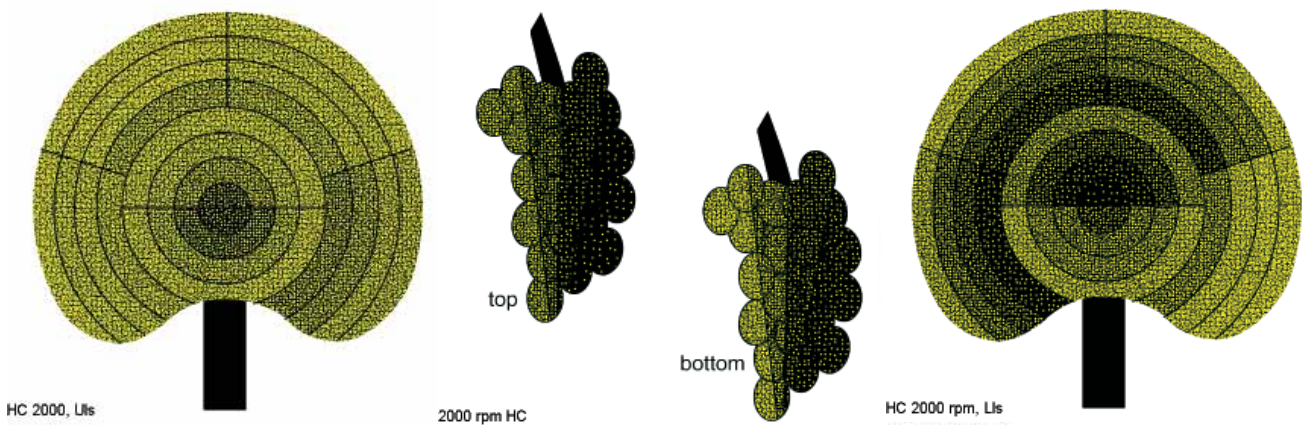


Table 1. Calculated sulphur deposits with a Quantum Mist sprayer based on visual ratings of the deposition of fine droplets

	mDN (a)	$\mu\text{l}/\text{cm}^2$ (b)	$\mu\text{g}/\text{cm}^2$ S (n)	$\mu\text{g}/\text{cm}^2$ S (o)
2000 rpm: fan rotational speed				
uls (1)	539	0.54	5.8	1.1
uls (2)	1247	1.25	13.5	2.5
lls (1)	421	0.42	4.5	0.84
lls (2)	1287	1.29	13.9	2.6
bs (1)	162	0.16	1.7	0.32
bs (2)	1095	1.1	11.8	2.2
1750 rpm: fan rotational speed				
uls (1)	507	0.51	5.5	1.0
uls (2)	1237	1.24	13.4	2.5
lls (1)	107	0.11	1.2	0.2
lls (2)	1240	1.24	13.4	2.5
bs (1)	126	0.13	1.4	0.3
bs (2)	1034	1.03	11.2	2.1
1500 rpm: fan rotational speed				
uls (1)	268	0.27	2.9	0.54
uls (2)	1247	1.25	13.5	2.5
lls (1)	37	0.037	0.4	0.07
lls (2)	1247	1.25	13.5	2.5
bs (1)	93	0.09	1.0	0.19
bs (2)	939	0.94	10.1	1.9

(a) Mean droplet number per cm^2

(b) Volume of spray liquid deposited

(n) Calculated quantity of sulphur deposited based on the lowest new label rate of 400 g/100 litres using distance based canopy size calibration (Furness 1998 and 2003 (a)) (giving a concentration factor of 2.7)

(o) Calculated quantity of sulphur deposited based on the old ha based label rate of 200 g/100 litres (equivalent to 2 kg/ha) for dilute spraying, using a spray volume of 20 litres per 100 m (equivalent to 670 litres per ha with a 3 m row spacing).

(uls) Upper leaf surface

(lls) Lower leaf surface

(bs) Bunch surface

(1) Mean for the lowest of the four ratings from the worst sprayed site in the canopy

(2) Mean for the highest of the four ratings from the best sprayed site in the canopy

Calculating sulphur dose (Furness 2000):

- Volume of spray deposited ($\mu\text{l}.\text{cm}^2$) = Droplet number/ $\text{cm}^2 \div 1000$ (for fine droplets only (in air vmd 125 microns, impacted vmd 250 microns))
- Chemical dose ($\mu\text{g}/\text{cm}^2$) deposited = $\mu\text{l}/\text{cm}^2 \times$ amount of chemical per 100 litres (label concentration) \times concentration factor $\div 100$

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References

- Furness, GO and Pinczewski, WV (1985). A comparison of the spray distribution obtained from sprayers with converging and diverging airjets with low volume air-assisted spraying in citrus and grapevines. *Journal of Agricultural Engineering Research* 32: 291-310
- Furness, GO (1998). Unit Canopy Row. A better way to calibrate your sprayer for fruit trees and grapevines. *Primary Industries and Resources SA, SARDI, Fact Sheet booklet number 12-98, ISSN 1323-0409, 8 pp*
- Furness, GO (2000). SARDI fluorescent pigment suspension concentrate. *Primary Industries and Resources SA, SARDI, Fact Sheet booklet 1-2000, 12 pp*
- Furness, GO (2002). A new fan for multi-head, air-assisted sprayers offers major improvements in pest and disease management. *The Australian and New Zealand Grapegrower and Winemaker, August 2002: 35-43*
- Furness, GO (2003)(a). Distance based calibration using the spray volume calculator. *Primary Industries and Resources SA/SARDI and Croplands Equipment Pty Ltd, booklet, 8 pp*
- Furness, GO (2003)(b). Distance calibration and a new pesticide label format for fruit trees and grapevines in Australia. *Proceedings, 7th Workshop on Spray Application Techniques in Fruit Growing, Cuneo, Italy, June 2003:293-303*
- Furness, GO (2003)(c). Commercialisation of the new SARDI fan: the influence of fan design on power efficiency, spray coverage and work rate with multi-fan sprayers. *The Australian and New Zealand Grapegrower and Winemaker, September 2003: 64-74*
- Furness, GO, Bollenhagen, LR and Packer JF (2003)(d). The influence of fan design on power efficiency, spray coverage and work rate with multi-fan sprayers. *Proceedings, 7th Workshop on Spray Application Techniques in Fruit Growing, Cuneo, Italy, June 2003: 19-33*
- Manktelow, DWL and MacGregor, A (2001). Independent report on the Quantum Mist™ grape sprayer. *Croplands Equipment Pty Ltd, Adelaide SA.*

Randall, JM (1971). The relationships between air volume and pressure on spray distribution in fruit trees. *Journal of Agricultural Engineering Research* 16: 1-31.

