EVALUATION OF LOW-VOLUME SPRAYING IN KIWIFRUIT

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SUMMARY

Tests were carried out on several hydraulic orchard sprayers operated at low volume settings. Mechanical evaluations included fan performance, tank agitation and spray nozzle characteristics. An adequate droplet size spectrum could be produced by selected hydraulic nozzles operated at 900 kPa and flows of 435 ml. In field trials on mature kiwifruit there were no differences in chemical leaf deposits, canopy penetration or residues on fruit at harvest when standard spray programmes were applied at 250, 500 or 2,200 litres/ha. Leafroller caterpillar populations were low at all water rates. Low volume spray applications are suitable for kiwifruit provided careful attention is paid to nozzle selection, calibration and operation of the sprayer.

INTRODUCTION

Spray applications of pesticides in kiwifruit are commonly made using high volume airblast sprayers at rates of 2000-2500 litres/ha. Even with a large tank on the sprayer, the area covered between fills is small, the weight of the sprayer can lead to soil compaction problems, and powerful tractors are required. Controlled droplet application (CDA) equipment allows water application rate to be greatly reduced (Jones *et al* 1983; Maber *et al* 1984; Umpelby 1984). This report examines the use of conventional airblast sprayers working at reduced water application rates.

Data on air velocities and nozzle droplet spectra, both of which affect spray coverage and penetration are summarised. Chemical residue measurements and insect population studies were used to assess the various trial applications.

METHODS

Field trials

In 1984-85 a full season spray programme was applied to mature kiwifruit blocks at Te Puke using a conventional airblast sprayer. Two blocks both under T-bar were divided to give three spray volume treatments: 2200, 250, and 500 litres/ha with three replicates.

A pergola block was divided to give two treatments: 2200 and 250 litres/ha with two replicates. The spray programme included azinphos-methyl (1.13 kg ai/ha) pre- and post- blossom followed by five chlorpyrifos (Lorsban 40EC) (0.54 kg ai/ha) applications at regular intervals up to 3 weeks prior to harvest. Vinclozolin (Ronilan) (1.13 kg ai/ha) was applied at blossom and pre-harvest.

In 1985-86 a second smaller trial was carried out on another Te Puke orchard. A full spray programme was applied to a 7-year old T-bar planting, with three unreplicated blocks being used for applications at 250, 500 or 2000 litres/ha. The spray programme applied was based on phosmet (Imidan 75) (2.55 kg ai/ha) as the main season insecticide.

Sprayer Calibration

Conventional airblast sprayers were used in both trials, (1984-85, and 1985-86). Spray droplet size and fan air velocity are two parameters which can greatly affect spray coverage and penetration. In the 1984-85 trial, detailed measurements of both parameters were made. The sprayer was fitted with Albuz hollow cone nozzles, and

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spray droplet size measurements were made using the laser diffraction technique (Fisher *et al* 1985).

Volume median diameter (VMD) and number median diameter (NMD) parameters were derived for a range of Albuz tips. Results for those nozzle tips used in the low volume application trials are listed in Table 1. The 250 litres/ha treatment used a mixture of Albuz 208 (0.8 mm dia) and 212 (1.5 mm dia) tips, 5 nozzles per side, operated at 900 kPa. The 500 litre/ha treatment used Albuz 212 and 220 (2.5 mm dia) tips, and 5 nozzles per side, operated at 1100 kPa. The 2200 litre/ha treatment used a separate bank of Masotti nozzle tips, 6 per side operated at 1450 kPa. Nozzle positions were adjusted between T-bar and pergola training system applications for all treatments to direct more spray into the denser part of the canopy, and some spray vertically upwards for pergola. Tractor speed was kept at 3.8 km/h for all treatments.

In the 1985-86 trial, a different model of airblast sprayer was used, and only flow rate checks were made for the Spraying Systems nozzles used. In the 250 litre/ha treatment, 6 Spraying Systems TX hollow cone nozzles per side were used, at 690 kPa gauge pressure. The 500 litre/ha treatment used 12 Spraying Systems TX nozzles per side, again operated at 690 kPa gauge pressure. The 2000 litre/ha treatment used 8 Spraying Systems disc and core nozzles per side operated at 1500 kPa gauge pressure. Ground speed was kept constant at 4.1 km/hr for all treatments.

Air Velocities

Spray droplet size, velocity, and the nature and shape of the target are interrelated with respect to the resulting spray coverage. The velocity of small spray droplets (less than 100 microns) is greatly influenced by the velocity of air from the fan.

In the 1984-85 trial, measurements of air velocity from the 810 mm diameter axial flow fan were made, both around the fan perimeter and at increasing distances from the fan.

Ground speed of the sprayer affects the rate at which air velocity decreases with increasing distance from the fan, so tests were made with the sprayer stationary, and at 4 km/h ground speed.

In the 1985/86 trial the sprayer used had a 720 mm diameter fan, and checks were made on air velocity around the fan perimeter, with the sprayer stationary.

Trial Assessments

Chemical residue measurements formed a significant part of the trial assessments. Sixty minutes following spray application samples containing 50, 20 mm leaf punches were taken from each treatment. For most of the sprays, specific areas of the canopy were sampled to assess spray penetration.

Leaf samples were shaken with toluene or petroleum ether and the extracts analysed using gas chromatography (Holland and McGhie, 1983). Results are expressed on a projected area basis and adjusted to the equivalent of a 1 kg/ha application rate to allow comparison amongst chemicals and trials.

Insect damage in the 1984/85 was assessed by orchard and harvest inspections. On three occasions (3.1.85, 25.3.85, 26.4.85) 100 fruit per replicate were inspected *in situ*. At harvest the main export picks were graded at the packhouse. The final picks were individually examined for live insects and damage caused by insects using 1000 fruit from each replicate.

In 1985/86 trial only final packhouse grade-out data were obtained.

RESULTS

Mechanical performance tests

Nozzle flow rates and droplet size data from the Albuz tips used in the 1984-85 trial are given in Table 1. Differences of 10-20% between the manufacturer's data and measured flow rates were found even though pressures were measured at the nozzle. Increased pressures resulted in decreases in both VMD and NMD measurements. The VMD/NMD ratio indicates the range of drop sizes present (a value of 1 would indicate that all droplets are the same size).

With the 810 mm fan at fine pitch, air velocity decreased from 24 m/sec at the outlet, down to 5 m/sec 3 m from the outlet. The air output at this setting was

TABLE 1: Nozzle performance data for Albuz hollow cone tips, 1984/85 trial.

Nozzle tip	Pressure (kPa)	Flow (measured) (litre/min)	VMD	NMD	VMD NMD
208 (0.8 mm dia)	900	0.44	75	11	6.8
	1300	0.52	72	9	8
212 (1.5 mm dia)	900	0.88	86	9	9.6
	1300	1.02	83	9	9.2
220 (2.5 mm dia)	900	1.52	91	11	8.3
	1300	1.66	83	9	9.2

Note: VMD = Volume median diameter
NMD = Number median diameter

approximately 19,500 m³/h. With the sprayer travelling at 4.0 km/h air velocity measurements made 1 m from the fan outlet were reduced to about 20% of the values recorded with the sprayer stationary.

With the 720 mm fan used in the 1985-86 trial, velocities around the fan perimeter (measured at the outlet) ranged from 26 to 32 m/sec.

Trial Assessments

Chemical residue measurements carried out following three sprays in the 1984/85 trial are summarised in Table 2 (two treatments). Table 3 contains the results from the two sprays sampled in the 1986 trial.

TABLE 2: Foliar pesticide residues produced by an airblast sprayer operating with different water rates, 1 h after application. ($\mu\text{g}/\text{cm}^2$ at 1 kg/ha application rate) 1984/85.

Application		T ₂ (250 litre/ha)		T ₁ (2200 litre/ha)	
		T-bar	Pergola	T-var	Pergola
29.11.84	O	6.2 ± 3.0	3.7 ± 0.2	4.2 ± 0.3	4.3 ± 0.6
vinclozolin	I	1.5 ± 0.5		2.1 ± 0.3	
3.1.85	O	1.5 ± 0.1	0.9 ± 0.6	3.5 ± 0.5	1.6 ± 0.2
chlorpyrifos	I	1.2 ± 0.2		1.7 ± 0.3	
9.3.85	O	5.8 ± 1.0	M 6.2 ± 1.5	4.3 ± 1.0	4.9 ± 1.3
chlorpyrifos	I	1.9 ± 0.4	S 1.1 ± 0.2	0.9 ± 0.4	1.6 ± 0.4

Note: I = Inner canopy, T-bar
O = Outer canopy, T-bar
M = Middle canopy, Pergola
S = Side canopy, Pergola

TABLE 3: Summary of leaf deposits using an airblast sprayer, 1985/86. ($\mu\text{g}/\text{cm}^2$ at 1 kg/ha application rate).

Application		250 litre/ha	500 litre/ha	2000 litre/ha
10.1.86				
phosmet	I	3.2 ± 0.2	3.5 ± 0.4	4.8 ± 0.3
	O	6.9 ± 0.5	6.9 ± 0.2	6.9 ± 0.3
25.3.86				
phosmet	I	7.0 ± 0.8	5.0 ± 1.0	6.3 ± 0.2
	O	8.6 ± 1.5	8.5 ± 1.4	9.4 ± 0.5

Note: O = outside canopy, T-bar
I = inside canopy, T-bar

In both trials, deposits on directly exposed foliage were consistently higher than leaves from the inner canopy, with no difference between treatments. The inner canopy around the central wire is the most difficult area of T-bar trained vines to cover. Deposits in this region during the 1984/85 trial were 20-50% of those on the outer, directly exposed canopy. Coverage of the inner canopy in the second trial was better than in 1984/85, probably because of a less dense canopy. The 9.3.85 sampling also indicated that the side row under canopy of pergola (under the main leader) received less spray than the centre row, due possibly to insufficient overlap of spray from individual nozzles.

There was no significant difference between high or low volume treatments, for either trial, in coverage obtained in the inner canopy.

The residue levels from the whole fruit at harvest in the 1984/85 trial showed no differences between treatments. Residue levels on fruit from pergola trained vines were highest, but all residues were within the maximum limits permitted for export fruit (2 mg/kg for chlorpyrifos).

Live caterpillars (*Stathmopoda* spp. and brown-headed leaf roller, *Ctenopseustis* spp.) and fresh fruit damage were found only during the first 1984/85 orchard inspection. All of the damage found at later inspections was old and healed. Damage levels were low at all assessments (0.5-3.0% of fruit) with no significant difference between treatments.

The harvest assessment of fruit from the final pick revealed very low levels of caterpillar chewing damage on all treatments. (Table 4). No fruit were infested with greedy scale (*Hemiberlesia rapax*). However a variety of mites and mealy bug were found at fairly uniform, low levels across all treatments, indicating that all application rates achieved a similar level of control.

The orchard inspections and harvest assessments did indicate a trend to lower insect levels on fruit under the pergola training system.

The packhouse assessment of export fruit reported zero rejection for leafroller damage or scale infestation for both the 1984/85 and 1985/86 trials.

TABLE 4: Percent damage or mean number of pests/1000 fruit at final pick (13.6.85).

Treatment	Training System	% Damage	Mean No./1000 fruit		
		Lepidoptera	Oribatid mites	<i>Anystis baccarum</i>	Mealybug
220 litre/ha	T-bar	0	33 ± 19	4.1 ± 1	2.7 ± 3
250 litre/ha		0	20.7 ± 9	1.3 ± 1	1.7 ± 1
500 litre/ha		0.3 ± 0.3	12.0 ± 4	3.7 ± 4	2.0 ± 1
2200 litre/ha	Pergola	0	11.0 ± 6	0.5 ± .5	0
250 litre/ha		0	2.0 ± 2	1.0 ± 0	0

DISCUSSION AND CONCLUSION

The main objective of both trials was to examine the performance of conventional airblast sprayers working at greatly reduced water rates. Earlier work (Maber *et al* 1984) had indicated that if spray droplet size was controlled, (by the use of a rotary atomiser for example), very low rates could successfully be used in kiwifruit spray programmes.

Spray droplet size is important in achieving good spray coverage. Matthews (1979) suggested an optimum droplet size range for foliage, and insects on foliage, of between 30 and 100 microns. With the Albuz tips used in the 1984/85 trial the amount of spray by volume with droplets in this size range was about 45%. No droplet size measurements were made of the Spraying Systems TX nozzles used in the 1985/86 trial, but they also are designed to produce small droplets.

Smaller droplets must travel at higher velocities to impact on a given target. Consequently the air velocity produced by the fan on an airblast sprayer is important. High velocities may damage the crop, and low velocities may result in poor droplet

deposition. Moreover, it is the relative velocity between droplet and target that is important, so foliage that is gently fluttered will enhance droplet deposition. Measurements of air velocity from the fans used in these trials suggests that velocities at the fan outlet should not exceed 30m/sec., otherwise damage to foliage will occur. It is more difficult to establish what the minimum velocity should be, but, by observation, air velocities of about 15 m/sec in the canopy may be appropriate.

Chemical residue measurements on leaves and on fruit inspection (for the 1984/85 trial) all indicate that spraying at 250 litres/ha gives the same adequate spray coverage as the 2200 litres/ha rate. Potential damage levels are unknown in the absence of unsprayed plots. However, leafroller moths flying into the orchards from outside could have established leafroller larval populations on treatment vines if insecticide coverage had been unsatisfactory. Greedy scale are less mobile and might take several seasons to build up to significant levels. The trials have not established whether low volume applications would provide adequate long term control of greedy scale. An assessment of fruit from two seasons, low volume CDA trials in 1982/83 (Maber *et al* 1984) indicated low levels of both leafroller and greedy scale. The spray residue results from both trials are similar to those from that 1982/83 trial, suggesting that, although inner canopy residues are lower, they are sufficient to obtain adequate pest control.

Results from these trials suggest that conventional air blast sprayers can successfully be used at very low water rates. However, droplet size (and hence nozzle selection) and fan air velocities should be selected within the limits suggested here. Accurate calibration is also essential, including measurement of nozzle flow rates, and use of the fluorescent dye technique to establish optimum settings is recommended.

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