Concentrated, low-volume aerial sprays to improve spray distribution in large avocado trees

R.E. Gaskin¹, K.D. Steele¹ and G.S. Elliott²

¹*Plant Protection Chemistry NZ, PO Box 6282, Rotorua 3043, New Zealand*

²*Etec Crop Solutions Ltd, PO Box 51584, Pakuranga 2140, New Zealand*

Corresponding author: robyn.gaskin@ppcnz.co.nz

Abstract The avocado industry has comprehensive guidelines for ground-based spray application to avocado orchards, but there are no current guidelines for aerial spray applications. Helicopter-applied deposits from a dilute spray application (600 litres/ha) of copper on a commercial Hass avocado orchard (12 m tall trees) were compared with two-times (300 litres/ha) and three-times (200 litres/ha) concentrate sprays with addition of varying rates of the superspreader adjuvant, Du-Wett®. Tartrazine dye was included as a deposit tracer. Concentrate sprays, with adjuvant addition, consistently gave higher spray deposits on difficult-to-wet fruit than the dilute aerial spray. Deposits on fruit in all canopy zones were increased with concentrate sprays, but particularly in the upper, lower and outer canopy zones. On foliage, concentrate sprays with adjuvant addition gave similar spray deposits to the dilute spray. Leaves in mid and inner canopy zones tended to be less well targeted by concentrate sprays. This must be considered if targeting dense trees with aerial sprays.

Keywords aerial pesticide sprays, avocado, *Persea americana* cv. Hass, adjuvant, concentrate spray, organosilicone.

INTRODUCTION

The avocado industry has comprehensive guidelines for dilute and concentrate ground-based spray application to avocado orchards (Manktelow & May 2006, 2009; Gaskin et al. 2008), but there are no current guidelines for aerial spray applications. The organosilicone superspreader adjuvant, Du-Wett®, has been shown to improve spray distribution and coverage on fruit and leaves in concentrate airblast sprays (Gaskin et al. 2008) and its use is recommended as Best Practice by the Avocado Industry Council. Aerial sprays are increasingly being employed to target pests and diseases

in tall, dense tree canopies. These sprays are typically applied in 600–700 litres/ha, but there is potential to substantially reduce application costs and improve pest and disease control by further reducing spray volumes (Gaskin et al. 2004). This study investigated the effect of concentrate sprays with Du-Wett® applied by air on the distribution of deposits on fruit and foliage of avocados.

METHODS

The trial was undertaken in October 2010 on a commercial orchard near Katikati consisting of 21 year old Hass avocado trees approximately

12 m tall. Trees were carrying a heavy flower crop and flowers were close to opening. All sprays (Table 1) were applied with a Squirrel AS350 BA helicopter through TeeJet XR8010SS nozzles on an 8 m boom. Flying speed and spray flow rate varied depending on the spray volume applied (Table 1). All sprays were applied in typical conditions for aerial application: 46% RH, 16°C, 1034 hPa air pressure, (northerly) wind speed 5–10 km/h.

Dilute spray application rate was in 600 litres/ha, 2× concentrate was in 300 litres/ha and 3× concentrate was in 200 litres/ha (Table 1). The 2× concentrate volume was achieved by blocking off alternate nozzles on the boom; the 3× concentrate volume was achieved by increasing the flying speed with 2× concentrate nozzling (Table 1). All treatments (Table 1) contained copper hydroxide (0.78 kg/ha, Kocide® Opti, Dupont NZ Ltd, WDG), with the addition of tartrazine food dye (approximately 2.5 g/litre) as a tracer. Adjuvants used (Table 1) were Latron® B-1956 (Dow Agrosiences) and Du-Wett (DW, Etec Crop Solutions). Treatment 1 was the standard control without superspreader addition. The use of Du-Wett is recommended for concentrate sprays only; its addition to dilute sprays may result in spray loss to run-off due to excessive wetting of plant surfaces.

Each treatment was applied to one large plot (ca 0.3 ha, containing up to 20 trees), running north-south in the orchard. Plots were separated by large, dense shelter belts on their east-west boundaries. Within each plot, four replicate trees were randomly selected before spraying and were

tagged and measured (Table 1). After the spray had dried, samples of fruit and foliage were taken from six canopy zones on each tree. The sample zones were the inner and outer canopy from lower, mid and upper tree height zones. The height zones divided the trees into equivalent sized sections: lower was <4 m high, mid was 4–8 m and upper was >8 m. The outer zone was directly exposed to spray and the inner zone was shielded from spray by outer zone foliage. At harvest, after spray had dried, two samples of four fruit and four samples of five leaves were collected from within each canopy zone (an equal number of samples from opposite sides of the tree) and placed into re-sealable plastic bags. In treatment 3, fruit was completely absent in most zones on all replicate trees and so no fruit was sampled. Samples were stored at 4°C until being washed within 24 h of spray application. Fruit was weighed prior to washing in 200 ml distilled water. Leaf samples were washed in 100 ml distilled water. Tartrazine dye deposits were quantified spectrophotometrically (427 nm). Leaf areas were determined post-wash using a Leaf Area Meter (Licor).

Fruit and leaf deposits were calculated as dose retained (µg/g and µg/cm², respectively). Fruit and leaf deposits cannot be compared directly because fruit deposits are calculated on a weight basis and leaf deposits on an area basis. All treatments contained the same amounts of copper and dye. Deposits in each treatment were normalised to an equivalent of 1 kg/ha dye application, based on spray sampled from the helicopter tank immediately pre- and post-spray.

Table 1 Description of treatments, aerial application parameters and tree sizes.

Tmt	Spray volume (litres/ha)	Spray concn factor	Adjuvant	Adjuvant rate		Flying speed (knots)/flow rate (litres/sec)	Mean tree height (m)
				ml/ha	%		
1	600	dilute	Latron B	150	0.025	14 / 3.2	11.0
2	300	2×	Du-Wett	200	0.067	14 / 1.6	12.4
3	300	2×	Du-Wett	300	0.10	14 / 1.6	12.5
4	200	3×	Du-Wett	200	0.10	19 / 1.6	11.6
5	200	3×	Du-Wett	300	0.15	19 / 1.6	13.2

Deposit data were normalised, transformed where necessary and compared using analysis of variance and LSD test ($P=0.05$) to determine the significance of treatment and canopy zone on spray deposits retained by fruit and foliage.

RESULTS AND DISCUSSION

Deposits on foliage

There was no effect of treatment on mean leaf deposits ($P=0.77$); all the low volume concentrate sprays were similar to the dilute control (Table 2). As is typical in many tree crops, the outer canopy received generally more than twice the deposits on the inner canopy foliage ($P<0.001$). Outer canopy deposits were similar for all treatments with the dilute control having the lowest value. However, inner canopy deposits were highest with the dilute control spray and significantly lower on foliage receiving $2\times$ (300 litres/ha), but similar to foliage receiving $3\times$ (200 litres/ha), concentrate sprays. The trend for concentrate sprays to reduce deposits on inner canopy foliage may be a cause for concern if applying aerial sprays to younger, denser avocado trees but is not likely to be an issue with large, more open canopies such as tested here.

Canopy height was highly significant ($P<0.001$), with the upper canopy receiving highest deposits, and mid and lower canopy zones receiving lower and similar deposits, ca 35% less (Table 2). Concentrating sprays did not significantly ($P=0.05$) reduce deposits on any canopy zone relative to the dilute spray; the general trend was for concentrate sprays to slightly increase deposits on the lower zone and

reduce them on mid zone foliage. Maintaining deposits on upper canopies with concentrate aerial sprays is the critical issue, because the tops of trees are generally not as well targeted as mid and lower canopies by ground-based sprayers (Gaskin et al. 2004, 2008). Additionally, the top of tall trees is where good control of pests such as leafroller is most difficult to achieve.

An examination of treatment deposits in all zones (Table 2) confirmed that all concentrate sprays and Du-Wett combinations provided similar deposits to the dilute control spray. Only one zone (inner-mid) in one concentrate treatment (300 litres + DW 200 ml) received significantly lower deposits than the dilute control (data not shown). Concentrate sprays tended to increase deposits on the outer canopy and this trend was more obvious in the $3\times$ than in the $2\times$ concentrate.

Deposits on fruit

Fruit numbers were very low and variable on trees in Treatment 3 and this treatment was therefore excluded from deposit analysis. Overall, fruit deposits were much more variable than for foliage. While leaves could be methodically sampled from all positions on trees, fruit was frequently clustered on a single side and was often scarce on inner and lower canopy zones.

The effect of treatment was highly significant ($P<0.001$) for overall deposits on fruit (Table 3). All concentrate sprays increased deposits on fruit relative to the dilute control and $3\times$ concentrate deposits were higher than $2\times$ concentrate. Fruit is moderately difficult-to-wet, much more so than the very wettable upper surface of avocado

Table 2 Retention of sprays ($\mu\text{g}/\text{cm}^2$, normalised for 1 kg dye/ha) on avocado foliage in different canopy zones with varying spray volumes and adjuvant rates.

Tmt	Treatment (concn factor)	Canopy zone					Mean
		lower	mid	upper	inner	outer	
1	600 litres (dilute) Control	0.87	1.17	1.65	0.99	1.47	1.23
2	300 litres ($2\times$) +DW 200	0.98	0.96	1.49	0.71	1.58	1.14
3	300 litres ($2\times$) +DW 300	1.05	1.00	1.48	0.68	1.66	1.17
4	200 litres ($3\times$) +DW 200	1.20	0.99	1.52	0.72	1.75	1.24
5	200 litres ($3\times$) +DW 300	1.09	1.09	1.58	0.81	1.70	1.25
LSD ($P=0.05$)		-----	0.34-----	-----	-----	0.28-----	NSD

leaves (Gaskin & Pathan 2006). Hence fruit is likely to benefit more than leaves from Du-Wett addition to increase deposits from aerial sprays.

As with foliage, the outer canopy tended to receive higher spray deposits than inner canopy fruit, but the differences between inner and outer zones were much reduced (Table 3). The most concentrated (3×) sprays increased deposits on inner and outer canopy fruit relative to the dilute control spray.

Canopy height was significant ($P<0.01$), with upper and lower zones tending to receive higher deposits than mid zone fruit (Table 3). This trend was observed consistently in concentrate spray treatments, but not in the dilute control, where the pattern was more as could be expected from an aerial spray with upper>mid>lower deposits. Fruit receiving concentrate 3× spray (200 litres/ha) + 300 ml/ha Du-Wett had significantly ($P<0.05$) higher deposits in all zones relative to the dilute control.

Such an increase in deposits raises the question of increased residues with concentrate sprays. An examination of results over 5 years of deposit studies (R.E. Gaskin, unpublished reports to Avocado Industry Council) indicates that the deposits from these concentrate aerial sprays are still well within the limits of deposits achieved by applying high volume, dilute sprays from ground-based sprayers. Residues from concentrate aerial sprays are very unlikely to exceed those resulting from current ground-based programmes.

CONCLUSIONS

Concentrate aerial sprays, with addition of Du-Wett, consistently gave higher spray deposits on

fruit, and similar deposits on foliage, relative to a dilute (600 litres/ha) spray with addition of Latron. Deposits on fruit in all canopy zones were increased with concentrate sprays containing Du-Wett, while foliage in mid and inner canopy zones tended to be slightly less well targeted by concentrate sprays with Du-Wett. This should be taken into account when spraying dense trees.

Deposits were generally highest in the most concentrated sprays, particularly on fruit, which is difficult-to-wet. This is likely to be a function of increasing the Du-Wett concentration as water volume is reduced. There was no marked effect of Du-Wett rate evident, but the higher rate of 300 ml/ha tended to give a slightly more even distribution of deposits over all canopy zones.

Overall, aerial application of both dilute sprays with Latron and concentrate sprays with Du-Wett to large open trees targeted upper and outer canopy zones well. Mid and lower inner/outer canopies were not targeted as well and will benefit from ground-based spray applications applied in parallel. Deposit distribution of concentrate aerial sprays on canopy zones in younger denser trees requires confirmation, particularly if ground-based sprays will not be used to support aerial sprays on such canopies.

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Table 3 Retention of sprays (µg/g, normalised for 1 kg dye/ha) on avocado fruit in different canopy zones with varying spray volumes and adjuvant rates.

Tmt	Treatment (concn factor)	Canopy zone					Mean
		lower	mid	upper	inner	outer	
1	600 litres (dilute) Control	0.36	0.46	0.57	0.40	0.52	0.46
2	300 litres (2×) +DW 200	0.96	0.41	0.79	0.60	0.83	0.72
4	200 litres (3×) +DW 200	1.12	0.78	1.41	0.97	1.24	1.10
5	200 litres (3×) +DW 300	1.32	0.89	1.10	0.96	1.25	1.10
LSD (P=0.05)		-----	0.40-----	-----	-----	0.32-----	0.23

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