ADJUVANT AND APPLICATION TECHNOLOGIES TO MINIMISE OFF-TARGET DRIFT FROM KIWIFRUIT SPRAYS

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ABSTRACT

The productivity and quality of the New Zealand kiwifruit crop depends on dormancy breaking sprays that are applied in high volumes to bare canes. The risk from off-target spray drift is high. This study investigated new nozzle and adjuvant technologies to improve the targeting of hydrogen cyanamide sprays and reduce off-target losses. The use of air inclusion (AI) nozzles could reduce vertical and horizontal drift of hydrogen cyanamide airblast sprays relative to conventional cone nozzles. The combination of an adjuvant with AI nozzles resulted in a significant decrease in off-target drift, by as much as 86% compared to current industry standard application methods. Deposits on target canes were not adversely affected by the use of AI nozzles and biological efficacy of the bud-breaking agent was maintained.

Keywords: hydrogen cyanamide, bud-breaking sprays, air inclusion nozzles, spray deposits, spray efficacy.

INTRODUCTION

Much of the New Zealand kiwifruit crop depends on hydrogen cyanamide dormancy breaking sprays to maximise vine productivity and fruit quality. These sprays are applied in high volumes to bare canes at which time the risk from off-target spray drift is high. Increasing intensification of land use at the rural-urban interface is increasing the demand for better management of spray risks. In addition, continued use of hydrogen cyanamide is currently under review by ERMA and the kiwifruit industry realises that new technologies are required to improve the sustainability of hydrogen cyanamide use.

Spray drift management legislation in Europe has driven the development of air-inclusion (AI) nozzle technology that can reduce spray drift. AI nozzles are widely used in Europe to reduce the risks of spray drift contamination of surface water courses (Anon. 2005). While this technology is well proven for use in arable crops, its effects on spray efficacy in fruit crops is not well understood. AI nozzles reduce drift by increasing droplet size through air inclusion, but larger droplets are known to impact less efficiently and give less even coverage on plant surfaces than the smaller droplets produced by the cone nozzles typically used in airblast applications (Webb et al. 2004). As such, the large droplets associated with AI nozzles could potentially reduce the biological efficacy of hydrogen cyanamide sprays. Spray adjuvants can improve adhesion and coverage of spray droplets and can also reduce off-target drift (Holloway 1994). The aim of this study was to assess the effects of two selected adjuvants and AI nozzles on the biological efficacy, on-target deposits and off-target drift of hydrogen cyanamide sprays.

METHODS

Chemical treatments

Four treatments (Table 1) and one unsprayed control were included in the trial. Hydrogen cyanamide (Hi-Cane, 520 g/litre, Nufarm Ltd) was applied at 18.72 kg/ha in 600 litres of water throughout. Two adjuvants were used at 0.25% v/v. Liberate (Elliott

Technologies Ltd) is a non-ionic spreader and anti-drift, with the ability to improve droplet adhesion and reduce fine droplets in the spray plume. It was included in a treatment with conventional nozzles to reduce off-target drift. Adjuvant NU0017 (Nufarm Ltd) is a spreader known to markedly improve droplet adhesion to plant surfaces and it also reduces driftable fines (i.e. droplets smaller than approx 100 μm in diameter) in sprays (R.E. Gaskin, unpubl. data). It has been shown previously to reduce downwind drift in spray applications to kiwifruit canes on T-bar canopies (D. Manktelow, unpubl. data). Tartrazine food dye (5 g/litre) was included in all treatments as a tracer to quantify spray deposits.

Sprayer set-up

The sprayer used was a Fantini airblast fitted with two spray rings. One ring was set with industry-typical cone nozzles to deliver a standard hydrogen cyanamide application of 600 litres/ha. The sprayer was operated by a spraying contractor and the operational parameters were considered typical of those currently used in the kiwifruit industry. The other ring was fitted with narrow angle, flat fan AI nozzles (Agrotop Turbodrop) and delivered 600 litres/ha with similar proportional volume outputs to the cone nozzles. Sprayer speed was 4.7 km/h for all applications. The fan was set at low pitch, with air velocities at the nozzles averaging 12-19 m/s (rear and front of air outlet duct, respectively) giving an air output volume ca 23,900 m^3/h.

Vines

All treatments were applied to mature cv. Hayward vines in a commercial block trained on a pergola system (within-row spacing 5.5 m; row width 4.6-5 m). Rows were oriented North-South. The canopy was pruned and tied down and was made up of one-year-old canes with a significant number of spurs and some previously fruited wood. Each treatment was replicated on two plots within the block, consisting of three bays (16.5 m long). Treatments were sprayed on the centre row of each plot and on one side of each adjacent row (spraying toward the centre row).

Cane selection and spray deposit assessment

Ten canes were randomly selected in the centre bay of each plot. These were sub-sampled into three (20 cm long) sections positioned (1) near the vine trunk, (2) centre of row and (3) at the small cane (growing) end, which was located near a vine trunk on the opposite side of the row. Cane diameters were recorded at both ends of the 20 cm sample. After spray had dried, individual cane samples were cut into pre-marked lengths and placed in resealable plastic bags. They were stored at 4°C until washed, within 24 h of spray application. Samples were washed in 200 ml distilled water and tartrazine dye deposits were quantified on a spectrophotometer (427 nm). Deposits were calculated as dose (μg/cm^2) normalised to 1 kg a.i. applied per ha.

Drift sampling and deposit assessments

Drift sampling was undertaken on both sides of the sprayed plots. During the day winds moved from E-NE to SE (blew consistently across the rows) and ranged in speed from 0-3 m/sec. Drift collection targets were plastic Petri dishes (85 mm diameter), placed horizontal to the ground and held in place by metal clips on sample poles. Sampling was undertaken at three heights above ground: 5 cm, 2.06 m (immediately above the pergola canopy) and 3.3 m (approx. 1.3 m above the canopy). Poles holding collectors were positioned at right angles to the sprayed row. Two replicates (approximately 5 m apart along the row) were located at three equidistant positions on either side of the centre bay of each sprayed plot. Poles were located at 9 m, 13 m and 17 m, either side, from the centre of the sprayed plot. After spray application, Petri dish collectors were sampled immediately into separate resealable plastic bags. They were washed in 25 ml distilled water, and tartrazine dye deposits were quantified as for canes.

Biological efficacy

Canes (12 per plot) were selected and tagged immediately post-treatment. Components of yield analysis were carried out on canes in all treatments and the untreated control as soon as flower buds were large enough to count easily (late October). Measurements included % bud break, % floral bud break, flower numbers per flowering shoot, king flowers per winter bud, lateral flowers per winter bud and phytotoxicity, as determined from the number of dead buds (McPherson et al. 2001).

Data analysis

Mean spray deposits on canes were statistically analysed by ANOVA (Statistix 8, Analytical Software, USA) to determine the significance ($P<0.05$) of treatment, cane replication and position in the pergola canopy. Additionally, hydrogen cyanamide residues (Hill Laboratories, Hamilton) and dye deposits were quantified in parallel on 20 random cane sections (diameters 3.9-12.1 mm) to determine the correlation between recoveries of dye and hydrogen cyanamide. Drift results were analysed to determine the significance ($P<0.05$) of treatment, height above ground and distance from sprayer for off-target spray deposits. Biological efficacy was also analysed by ANOVA, but because the number of replicates was low and variability high, probabilities were highlighted at $P<0.20$ to indicate treatment effects.

RESULTS AND DISCUSSION

Deposit assessments

Parallel analysis of tartrazine dye and hydrogen cyanamide deposits in cane washes demonstrated that dye recoveries are a good estimate of hydrogen cyanamide deposits ($R^2=0.79$) at the typical hydrogen cyanamide levels expected for efficacy on dormant canes, i.e. 50-80 µg/cm^2 (Fig. 1).

There were no differences between conventional treatments with respect to spray deposits retained on canes (Table 1). Anti-drift adjuvants usually decrease drift by reducing the formation of fine droplets (Downer et al. 1995). This may reduce on-target deposition, due to the increased bounce of larger droplets. This effect was not observed here. While anti-drift adjuvant addition resulted in the lowest cane deposits and smaller canes tended to receive lower deposits, these were not significantly less than the conventional treatment minus the anti-drift adjuvant.

Large droplet sizes are usually associated with poor droplet deposition and adhesion, but the air inclusions in large droplets from AI nozzles appear to improve deposition, possibly as a result of decreased impact bounce. In this study, AI nozzles deposited significantly more spray overall (+10%) on bare canes than the conventional airblast application (Table 1). Adjuvant NU0017 had no effect on cane deposits from AI nozzles. Based on these results, AI nozzles, with or without NU0017 addition, have the potential to substitute for conventional nozzles without adversely affecting hydrogen cyanamide deposits on canes.

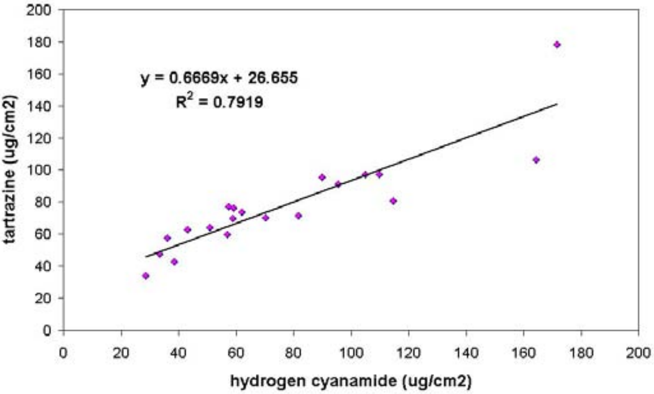

FIGURE 1: Correlation of dye and hydrogen cyanamide deposits (at equivalent application rates) recovered from 20 random canes.

Cane position on the pergola had no effect on deposits (Table 1). While the pergola canopy is a relatively easy spray target compared to T-bar and tree canopies, the trunk region is most distant from the sprayer and is most likely to receive lower deposits from poorly set up sprayers (D. Manktelow, unpubl. data). In this study, spray was evenly distributed on all cane positions.

TABLE 1: Spray deposits (µg/cm^2), normalised to a 1 kg/ha application rate of tartrazine dye, on canes from hydrogen cyanamide sprays applied by different nozzles without and with adjuvants.

	Cane position in pergola canopy[1]			Overall
Treatment description	near trunk	centre	small cane end	mean
Conventional nozzles	5.40 bc	5.21 bc	5.22 abc	5.28 B
+ anti-drift adjuvant	5.13 bc	4.81 c	4.94 c	4.96 B
AI nozzles	5.49 abc	6.00 ab	6.07 a	5.85 A
+ NU0017 adjuvant	5.54 abc	5.49 abc	5.30 abc	5.44 AB
Cane position mean	5.39	5.38	5.38	–

[1] Means within the table sharing common postscripts are not significantly different (LSD P=0.05).

Drift assessment

Nozzles and adjuvants had no effect on upwind, but a large effect on downwind off-target drift (Tables 2 & 3). While the anti-drift adjuvant and AI nozzles tended to reduce the distance spray drifted further than 9 m downwind, the combination of AI nozzles+NU0017 adjuvant did so significantly, by >85% compared to the conventional control (Table 2). This effect was also very visible during the actual spraying. The spray cloud from AI nozzles+NU0017 adjuvant travelled a lesser distance downwind (Table 2) and attained less height above the canopy (Table 3) than any other treatment, and its spray plume dropped out of the air immediately after the sprayer airblast stream passed by. Drift deposits at 1.3 m above the canopy (3.3 m above ground) from AI nozzles+NU0017 adjuvant were <25% of those from the conventional control (Table 3). The addition of NU0017 adjuvant to AI sprays had a significant effect (P=0.05) on height and distance of downwind drift. While the high leaf indices and the boundary shelter of kiwifruit orchards containing vines in full leaf may result in only 2% of sprays leaving the block as drift (Holland et al. 1997), the risk of off-target movement from hydrogen cyanamide sprays applied to bare canes is far greater. Continued use of this dormancy breaking agent by the industry depends on reducing that risk. The combination of AI nozzles+NU0017 adjuvant has the potential to reduce the off-target drift of hydrogen cyanamide applications markedly.

Biological efficacy assessment

Hydrogen cyanamide acts by increasing the number of winter buds that break on each cane and the number of king flowers/winter bud. An increase in floral shoots and flowers/shoot is not unusual with this chemical. An additional benefit of hydrogen cyanamide is that it thins lateral flowers, an expensive task to do by hand.

Application of hydrogen cyanamide through AI nozzles was effective in that both bud break and king flowers/winter bud were increased above levels recorded on control canes (Table 4), but there was extreme natural variability between replicates and no significant differences between conventional and AI nozzles were apparent. The values given are means (n=24) for the main effects. There were very few lateral flowers on any canes in this season and so the thinning aspect of hydrogen cyanamide efficacy could not be tested. There was no bud damage on any cane assessed. Hydrogen cyanamide bud-breaking efficacy was maintained with the use of AI nozzles, and with the addition of NU0017 adjuvant.

TABLE 2: Spray deposits (ng/cm^2), normalised to a 1 kg/ha application rate of tartrazine dye, recovered from drift collection poles at varying distances from the spray output. Sprays were applied by different nozzles with and without adjuvants.

		Conventional nozzles		AI nozzles	
Pole position		No adjuvant	anti-drift adjuvant	No adjuvant	NU0017 adjuvant
upwind	+9 m	51[1]	29	16	50
	+13 m	78	25	10	22
	+17 m	22	63	13	26
	upwind mean	50	39	13	33
downwind	+9 m	199	294	341	27
	+13 m	195	125	35	24
	+17 m	128	45	58	20
	downwind mean	174	155	145	24
Treatment mean[2]		112 A	97 A	79 A	28 B

[1] Treatment*pole position LSD (P<0.05)=98.1.

[2] Treatment means sharing common letters are not significantly different (LSD, P<0.05).

TABLE 3: Spray deposits (ng/cm^2), normalised to a 1 kg/ha application rate of tartrazine dye, recovered from drift collectors positioned on poles at three different collector positions (height above ground). Sprays were applied by different nozzles with and without adjuvants.

		Conventional nozzles		AI nozzles	
Collector position		No adjuvant	anti-drift adjuvant	No adjuvant	NU0017 adjuvant
upwind	0.05 m	77[1]	55	11	34
	2.06 m	44	32	16	33
	3.30 m	29	30	13	31
downwind	0.05 m	277	152	257	29
	2.06 m	145	162	107	18
	3.30 m	100	150	70	24

[1] Treatment*collector position LSD (P<0.05)=69.4.

TABLE 4: Mean bud break (%) and flowering attributes for hydrogen cyanamide sprays applied by different nozzles with and without adjuvants.

Treatment	Bud break[1] %	King flowers/ winter bud	Floral shoots[1] (%)	Flowers /shoot	Lateral flowers[1] (%)
Untreated control	41.2 (39.9)	1.08	81.8 (64.7)	3.53	0.10 (1.78)
Conventional nozzles	51.2 (45.7)	1.58	87.9 (69.7)	3.76	0.19 (2.48)
+ anti-drift adjuvant	50.9 (45.5)	1.59	89.2 (70.9)	3.78	0.12 (2.00)
AI nozzles	56.6 (48.8)	1.30	73.8 (59.2)	3.32	0.05 (1.25)
+ NU0017 adjuvant	48.1 (43.9)	1.38	87.2 (69.1)	3.41	0.14 (2.16)
LSD (P<0.20)	(3.61)	0.26	(9.12)	0.35	0.14

[1] Values were back-transformed to the original (%) scale with transformed means in parentheses for comparison purposes using the associated LSD values.

CONCLUSIONS

AI nozzles are an exceptional tool to reduce off-target drift of hydrogen cyanamide sprays applied to kiwifruit pergola canopies. In combination with NU0017 adjuvant, AI nozzles significantly and substantially reduced both horizontal and vertical spray drift compared with current industry standard application methods. Deposits on canes were not adversely affected and bud-breaking efficacy of sprays was maintained. However, due to the variability of bud-breaking response in this 2005 study, quantifying the effect of AI nozzles+NU0017 adjuvant on the efficacy of hydrogen cyanamide over at least two additional seasons is regarded as essential to confirm their benefits.

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