A COMPARISON OF STICKER ADJUVANTS FOR THEIR EFFECTS ON RETENTION AND RAINFASTENING OF FUNGICIDE SPRAYS

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ABSTRACT

Sticker adjuvants enhance adhesion of pesticide sprays to plant surfaces and increase their resistance to rain. This study evaluated the effect of two different sticker adjuvant types, organosilicone/latex and terpene based polymers, on the retention and rainfastness of a protectant fungicide, tolyfluanid, on *Vicia faba* (broad bean) and/or *Brassica oleracea* (cabbage) foliage. On hard-to-wet cabbage, the organosilicone/latex stickers provided better spray retention than the terpene polymers. Increasing rates of the former resulted in increased retention of spray, while use rate had no effect on terpene polymer performance. After 4 mm rain (applied as a heavy rain event), up to 86% of fungicide deposits applied with organosilicone/latex stickers were retained on cabbage. In comparison, <45% of deposits containing terpene polymers were retained post-rain. On easy-to-wet broad bean foliage, pre-rain deposits containing terpene stickers were approx four-fold higher, and post-rain deposits were much greater, than on cabbage. There were differences in retention and rainfastening properties between commercial stickers of the same chemical type.

Keywords: terpene, polymer, organosilicone, latex, *Vicia faba*, *Brassica oleracea*, rainfast, foliage.

INTRODUCTION

Sticker adjuvants, such as terpenes and synthetic latex polymers, increase the adhesion of pesticide sprays to plants and form a protective film over the target surface. These properties can increase the resistance of pesticide deposits to rain wash-off (Thacker & Young 1999). The terpene adjuvants, once applied to a leaf surface, auto-polymerise with exposure to air and UV light to form a film. These adjuvants require at least 30 min of sunlight after the spray has dried for the polymer to set and become rainfast (Anon. 2009). In contrast, the latex polymers are rainfast as soon as the spray dries (Anon. 2009). Neither type of adjuvant provides improved spreading or coverage to pesticide sprays (Holloway et al. 2000; R.E. Gaskin, unpubl. data). Latex stickers blended with organosilicone superspreaders have been developed in recent years to provide better spreading properties (Gaskin et al. 2000), but such blends can have disadvantages. For example, too much spreading may reduce the film thickness and protective properties of the latex sticker.

This study compared the retention and rainfastness of a fungicide spray when applied with either terpene sticker adjuvants or latex/organosilicone type sticker/spreader adjuvants. All adjuvants were tested on a difficult target, i.e. hard-to-wet foliage, and performance of the terpene stickers was also evaluated on an easy-to-wet plant.

METHODS

Brassica oleracea (cv. Napoleon F1; cabbage) and *Vicia faba* L. (cv. Evergreen; bean) seedlings were grown from seed in 9 cm diameter pots for 4 weeks, to the 4-6 leaf stage, in a controlled environment (20/15°C day/night, 75% relative humidity,

12 h photoperiod, $\sim 500 \mu\text{mol}/\text{m}^2/\text{sec}$ light). Sprays were applied with a calibrated moving head tracksprayer. All sprays contained the tartrazine food dye (Exagran Granular, Hawkins Watts Ltd, 5 g/litre) and the fungicide tolyfluanid (Euparen Multi®, Bayer, 1.25 kg ai/ha). This contact protectant fungicide (WDG formulation) is susceptible to rain wash-off. The label advises that rain within 3 h following treatment may reduce its effectiveness and it is commonly applied with a sticker adjuvant to improve its ability to withstand rain. Treatments contained one of four sticker adjuvants to compare their retention properties and their rainfastening of the fungicide deposits. Bond® Xtra (organosilicone/latex polymer blend, Elliott Technologies Ltd), Du-Wett® Rainmaster™ (organosilicone/latex polymer blend, Elliott Technologies Ltd), Nu-Film-17® (terpene polymer, Key Industries Ltd) and FilmStar® (polymerised terpene/fatty alcohol blend, Elliott Technologies Ltd) were applied at two recommended rates (Table 1). Treatments were applied at either 500 or 200 litres/ha (Table 1), representing typical dilute and concentrate fungicide applications, respectively, made to vegetable crops. Treatments were applied through a Twinjet TJ 60 8002EVS nozzle at 250 kPa, positioned 50 cm above the mean plant height, to 26 replicate plants of each species. Four artificial targets, mounted horizontally under the sprayer, were sprayed in all treatments to accurately confirm the spray volume delivered.

After spraying, artificial targets and 15 replicate plants (three largest leaves per plant) from each treatment were sampled and washed immediately in distilled water (200 ml) in individual resealable plastic bags. The tartrazine dye recovered in washes was quantified spectrophotometrically (427 nm). Leaf areas were determined using a Leaf Area Meter (Licor LI 3100A). Leaf deposits, i.e. pre-rain retention, were calculated as dose ($\mu\text{g}/\text{cm}^2$).

One replicate plant (three largest leaves per plant) from each treatment was sampled, unwashed, as a pre-rain control for residue analysis. The 10 remaining replicate plants in each treatment were left to dry in full natural sunlight. Treatments containing the latex spreader/stickers were dry in <30 min, after which they were exposed to artificial rain. This was applied as a 'heavy rain' event (Keeney & Valcore 1996); 15 mm/h for 15 min, providing a mean rainfall of 3.8 mm total. Treatments containing the terpene polymer stickers were left in full sun for 60-90 min post-spray to cure the terpene polymer before being exposed to artificial rain. All plants were left under cover for 24 h to dry. Replicate plants were sampled individually (three largest leaves per plant) into plastic bags and sent immediately for tolyfluanid residue analysis (RJ Hill Ltd, Hamilton). A constant, known area of leaf was sampled for analysis and residue results were provided as μg tolyfluanid/ cm^2 tissue for each replicate sample. The pre-rain controls analysed for tolyfluanid residues gave similar recoveries to the dye wash-offs; on bean the recovery was identical, on cabbage the residue recovery was within one standard deviation of the dye deposit mean.

Residue data were used in conjunction with pre-rain spray retention data to determine rainfastness (% ai retained on leaves after rain) provided by the adjuvants. All results were normalised at 1 kg/ha application and mean spray deposits were analysed by ANOVA (Statistix 8, Analytical Software, USA) to determine the significance (LSD test, $P=0.05$) of adjuvant treatment on pre- and post-rain deposits.

RESULTS AND DISCUSSION

Plant species were chosen in order to provide different leaf surface characteristics. At the growth stages used, the foliage of both cabbage and bean was an essentially horizontal target for sprays, but cabbage is classified as a very waxy, difficult-to-wet species with an adaxial leaf contact angle of 120° (Gaskin et al. 2005), while less waxy bean foliage is easily wettable with a contact angle of 68° .

The fungicide spray was not applied in the absence of adjuvants in this study because it is well-established that it lacks rainfastness (Anon. 2009). There were differences between adjuvants in the pre-rain retention of fungicide sprays on waxy cabbage (Table

1). The sprays containing organosilicone/latex stickers were retained up to three times better than those containing terpene stickers. Adhesion and retention of spray droplets on difficult-to-wet foliage is very poor in the absence of adjuvants (Gaskin et al. 2005) and such differences between adjuvants are well established (Holloway 1994; Holloway et al. 2000). Retention increased with increased concentration of the organosilicone/latex blend type adjuvants; addition of Du-Wett Rainmaster, at the higher rate, provided maximum retention and more than Bond Xtra at that same rate ($P < 0.05$, Table 1). Bond Xtra has been shown previously to increase retention and coverage of sprays on difficult-to-wet foliage (Gaskin et al. 2000). Both terpene stickers performed similarly on cabbage ($P > 0.05$) and a large increase in their use rate had little effect on initial (pre-rain) spray deposits (Table 1). This suggests that the terpene adjuvants have little effect on droplet adhesion and confirms that they are not good adjuvants for improving spray retention on difficult-to-wet species compared to the organosilicone/latex stickers.

TABLE 1: Mean tolyfluand deposits retained on difficult-to-wet cabbage seedlings, before and after rain, with adjuvant addition.

Adjuvant	Spray vol		Pre-rain deposit	Post-rain deposit	
	ml/ha	litres/ha	$\mu\text{g}/\text{cm}^2$	$\mu\text{g}/\text{cm}^2$	% of pre-rain
Bond Xtra	300	200	3.89 cd	0.91 cd	23.3
Bond Xtra	600	200	5.05 b	3.36 b	66.5
Du-Wett Rainmaster	300	200	4.84 bc	4.15 b	85.7
Du-Wett Rainmaster	600	200	6.58 a	5.66 a	86.1
Nu-Film-17	300	500	1.88 f	0.37 d	19.8
Nu-Film-17	1250	500	2.86 de	0.91 cd	31.6
FilmStar	300	500	2.46 ef	0.60 cd	24.2
FilmStar	1250	500	2.64 ef	1.17 c	44.3

Means within columns sharing common postscripts are not significantly different (LSD: $P = 0.05$)

Post-rain deposits were consistently higher with Du-Wett Rainmaster than with Bond Xtra (Table 1). Increasing the use rate of Bond Xtra increased its ability to protect the fungicide spray dose from rain wash-off, due to the increased concentration of latex in the spray. This effect was not observed with Du-Wett Rainmaster, suggesting that its latex composition is higher than for Bond Xtra and it protects deposits against rain wash-off at a lower use rate. After the heavy rain event, up to 86% of fungicide deposits applied with organosilicone/latex stickers were retained on waxy cabbage leaves. In comparison, <45% of deposits containing terpene stickers were retained post-rain (Table 1). Similarly to pre-rain retention of sprays, there were no differences in the rainfastening properties of the two terpene stickers, although the trend was for FilmStar to perform better than Nu-Film-17.

Spray retention on wettable species is always much greater than on difficult-to-wet species and the former often benefits little from the addition of adjuvants. Superspreading organosilicone adjuvants should only be used with care on easy-to-wet species because they can reduce retention through spray run-off (Holloway et al. 2000). The organosilicone/latex stickers were not tested on bean in this study. Pre-rain retention of sprays containing the terpene stickers was approximately four-fold higher on bean (Table 2) than on cabbage (Table 1), but this is primarily as a result of the target surface wettability (Gaskin et al. 2005) and not the adjuvant properties per se. It has been reported that the terpene adjuvants increase spray retention on easy-to-wet bean foliage by less than 20% (Holloway et al. 2000).

TABLE 2: Mean tolyfluanid deposits retained on easy-to-wet bean seedlings, before and after rain, with addition of terpene polymer adjuvants.

Adjuvant	ml/ha	Spray vol litres/ha	Pre-rain deposit $\mu\text{g}/\text{cm}^2$	Post-rain deposit	
				$\mu\text{g}/\text{cm}^2$	% of pre-rain
Nu-Film-17	300	500	9.48 b	5.34 ab	56.3
Nu-Film-17	1250	500	9.34 b	5.99 a	64.1
FilmStar	300	500	10.29 ab	3.81 b	37.0
FilmStar	1250	500	11.00 a	4.56 ab	41.5

Means within columns sharing common postscripts are not significantly different (LSD: $P=0.05$)

There was little difference ($P>0.05$) between the performances of the two terpene stickers. FilmStar provided marginally higher initial deposits, but Nu-Film-17 tended to protect deposits on the wettable bean leaves from rain wash-off slightly better (Table 2). Thus, there were no differences between the two adjuvants in mass fungicide deposits left on the plant surface post-rain, and these were much higher than on waxy cabbage.

CONCLUSIONS

On hard-to-wet foliage, organosilicone/latex stickers provided superior retention and rainfastness of a fungicide spray relative to terpene polymer stickers, and at lower use rates. Du-Wett Rainmaster performed better as a sticker adjuvant than Bond Xtra. The terpene stickers, Nu-Film-17 and FilmStar, performed similarly to each other on both waxy and wettable plant species but their ability to improve the resistance of fungicide spray deposits to rain wash-off was far greater on the easy-to-wet foliage.

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