Adjuvant Effect on Spray Droplets

Peter Jones
Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

Summary:

This paper investigates the effects that tank mix spray adjuvants have on the size of droplets emanating from nozzles typically used in Australian agriculture. Results show that wetting agent adjuvants generally reduce the size of spray droplets whilst oil-based adjuvants tend to increase droplet size, however at least one exception to this general rule has been identified. Whilst the effect adjuvants have on the droplet size should be taken into account when planning a spray application, other factors such as choice of nozzle type and size, operating pressure, height of boom and environmental conditions all play a significant role in the outcome. Adjuvants should not be relied on to manage the issue of off-target drift.

Introduction:

When applying an agricultural chemical to a crop or field to control pests or promote positive effects, the products are generally applied as a water based spray. To optimise the efficacy of the spray, it is desirable for the spray droplets to be a certain size as recommended by the product manufacturer (eg. fine, medium or coarse). Generally speaking droplets which are too small will tend to drift too easily and miss the target and may even cause damage away from the target whilst droplets too large will tend to bounce or run off the target resulting in uneven coverage.

Nozzle manufacturers have designed nozzles to produce uniform output (uniform quantity across a swath width and uniform droplet size) and make recommendations to the rate of output and the droplet size expected from each nozzle.

Nozzle manufacturers generally calibrate their systems using pure water but in the field products are always added to water for spraying and this document aims to help users understand what may happen to spray droplets when an adjuvant product is added to the spray mix.

Victorian Chemicals has undertaken a series of experiments to determine the effect that tank mix adjuvants can have on the size of spray droplets formed from hydraulic nozzles.

Materials and Methods

The droplet size distribution generated by the nozzles at different pressures and spray mixtures was measured with a laser-diffraction particle-size analyser
The majority of the data presented in this document relates to Flat Fan nozzles (typically XR11002) with a brief section on other nozzles (AIXR11002 & TT11002) included in Figures 5 & 6.

Each Figure presented below shows droplet distribution for a range of adjuvant products as a solution in water. All of the solutions used in Figures 2 and 5 also contain the Glyphosate product RoundUp CT @ 3% in Figure 2 and @ 2.5% in Figure 5. Figures 1, 3, 4 & 6 are for adjuvants alone in water.

The Particle Size is always reported as micron and the relative distribution is presented as a proportion of the spray volume. In the legend for each Figure, the proportion of fine droplets (<150 micron) is reported in the first column and the volume mean diameter (vmd) is reported in the second.

A list of all of the products shown in any of the Figures and the dilution rate at which they were used is at the end of the document in Table 1. Typically the usage rates are at or near the maximum usage rate for each product. Other dilution rates have been investigated (not reported) for most of these products but generally the droplet size distribution is not particularly rate sensitive, but is much more dependent on the type of adjuvant product.

Adjuvants alone in Water compared with Adjuvants + RoundUp CT in Water.

In this study, a single nozzle was selected (XR11002) and all data was generated at a constant operating pressure of 2.5bar. Solutions of adjuvant products alone in water were atomised and the droplet distribution measured (see Figure 1). The same set of adjuvants were then prepared in solution with RoundUp CT then atomised and the droplet distribution measured (see Figure 2).

Adjuvant Effect on Spray Droplets

Peter Jones
Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

FIGURE 1: Particle Size distribution for adjuvants in water through XR11002 nozzle at 2.5 bar pressure

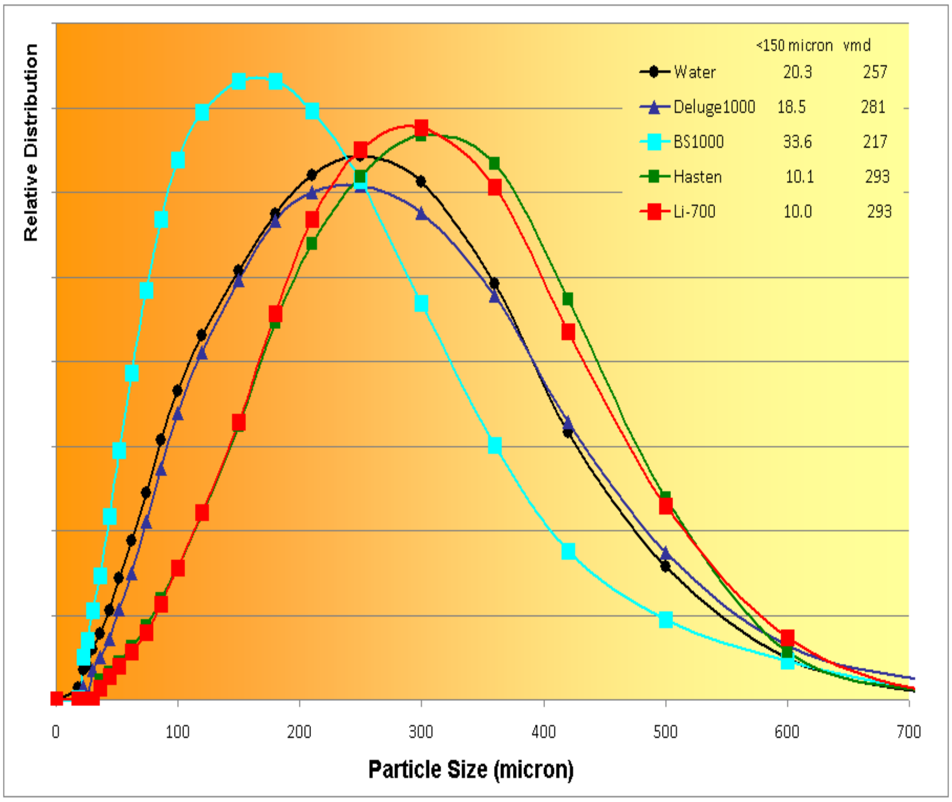
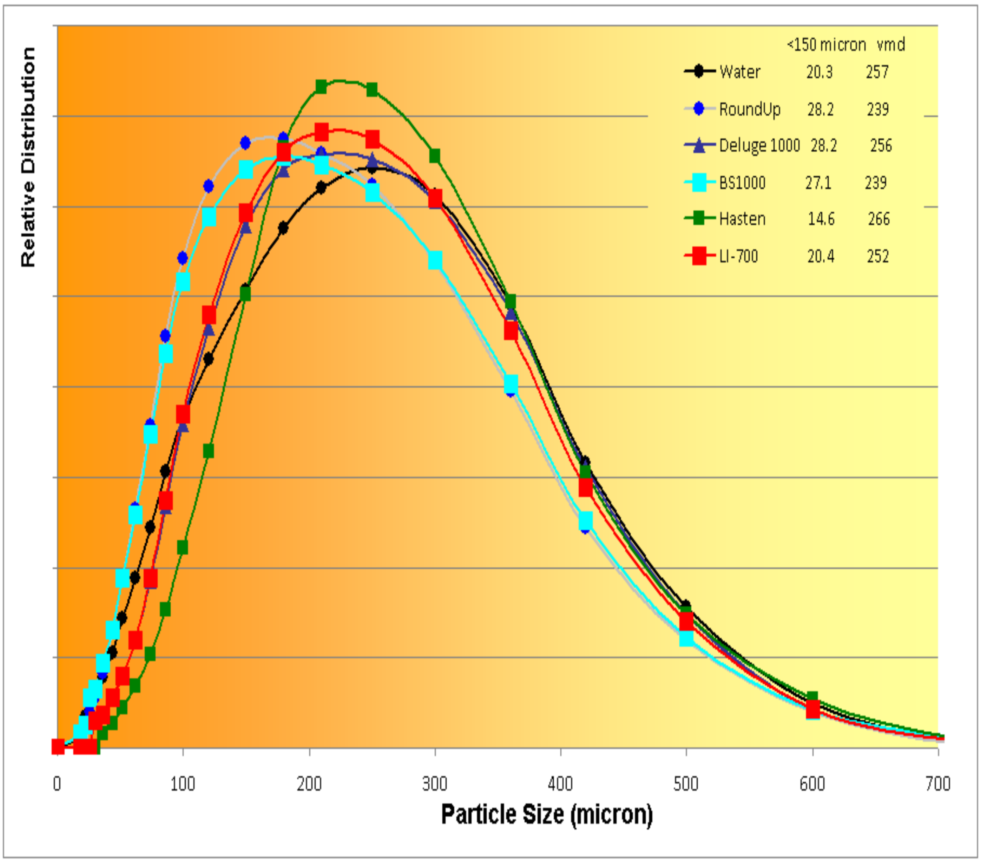


Figure 1 shows that when an adjuvant product was added to water and sprayed through a Flat Fan nozzle the droplet size distribution is changed. Certain products reduced the droplet size compared with water alone, whilst others increased the droplet size. Generally products which rapidly reduce surface tension such as the wetting agent BS1000 will reduce the droplet size whilst oil based adjuvants such as Hasten will increase the droplet size. Note that the wetting agent Deluge 1000 slightly increased the average droplet size whilst the adjuvant LI-700 increased the droplet size in a way more commonly associated with oil based adjuvants such as Hasten. More detailed comparative examples of Wetting Agents and Oil Adjuvants follow in Figures 3 & 4.

FIGURE 2: Particle Size distribution for adjuvants with RoundUp CT (3%) through XR11002 nozzle at 2.5 bar pressure

Figure 2 shows that when an adjuvant product was added to solution containing the herbicide RoundUp CT, it influenced the droplet size in a similar way to that of the adjuvant alone in water (Figure 1). Firstly note that RoundUp CT contains surfactants (similar to those in BS1000) and hence when compared with water alone, it reduces the droplet size markedly. The adjuvant products which increased the droplet size of water (Hasten and LI 700) also increased the droplet size of RoundUp CT solution and those which reduced the droplet size of water (BS1000 and to a lesser extent Deluge 1000) either reduced or maintained the smaller droplet size of the RoundUp CT solution. This effect was consistent throughout this series of studies so that the effect an adjuvant product had on the droplet size of a herbicide solution could be predicted by measuring the droplet data of the adjuvant product alone in water.



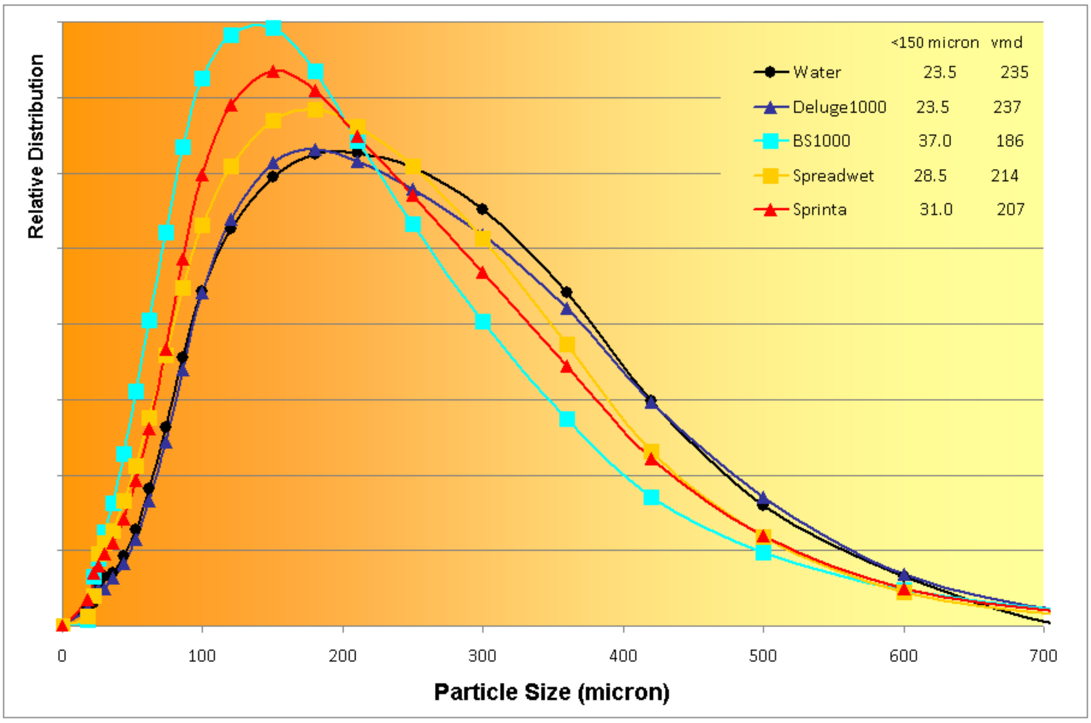
Peter Jones

Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

Wetting Agent Adjuvants in Water

This study (Figure 3) compared a group of nonionic wetting agents for their effect on droplet size. Details of the products are shown in Table 1 – note that this group of wetting agents encompasses essentially all of the common types of product available as wetting agents for Australian ag Most of the products tended to reduce the average droplet size or increase the proportion of smaller droplets. BS1000 tended to reduce droplet size most significantly whilst Deluge 1000 had the least effect of reducing droplet size.

FIGURE 3: Particle Size distribution for wetting agents in water through XR11002 nozzle at 2.5 bar pressure



Oil-based Adjuvants in Water

A series of oil based adjuvant products generally increased droplet size when compared with water alone. The key differences between these oil products are either the type of oil (esterified vegetable, vegetable or mineral (aka petroleum or paraffinic)) or the proportion of surfactants (emulsifiers) in the product.

Effects from oil type: Generally the esterified vegetable oil and vegetable oil products had a greater effect in increasing droplet size compared with the mineral oils. Eg Hasten (esterified vegetable), Nexus (vegetable) and Envoy (vegetable) all produced larger vmd than Ad-Here, Empower, InBound, UpTake and Hot-Up (all contain mineral oil).

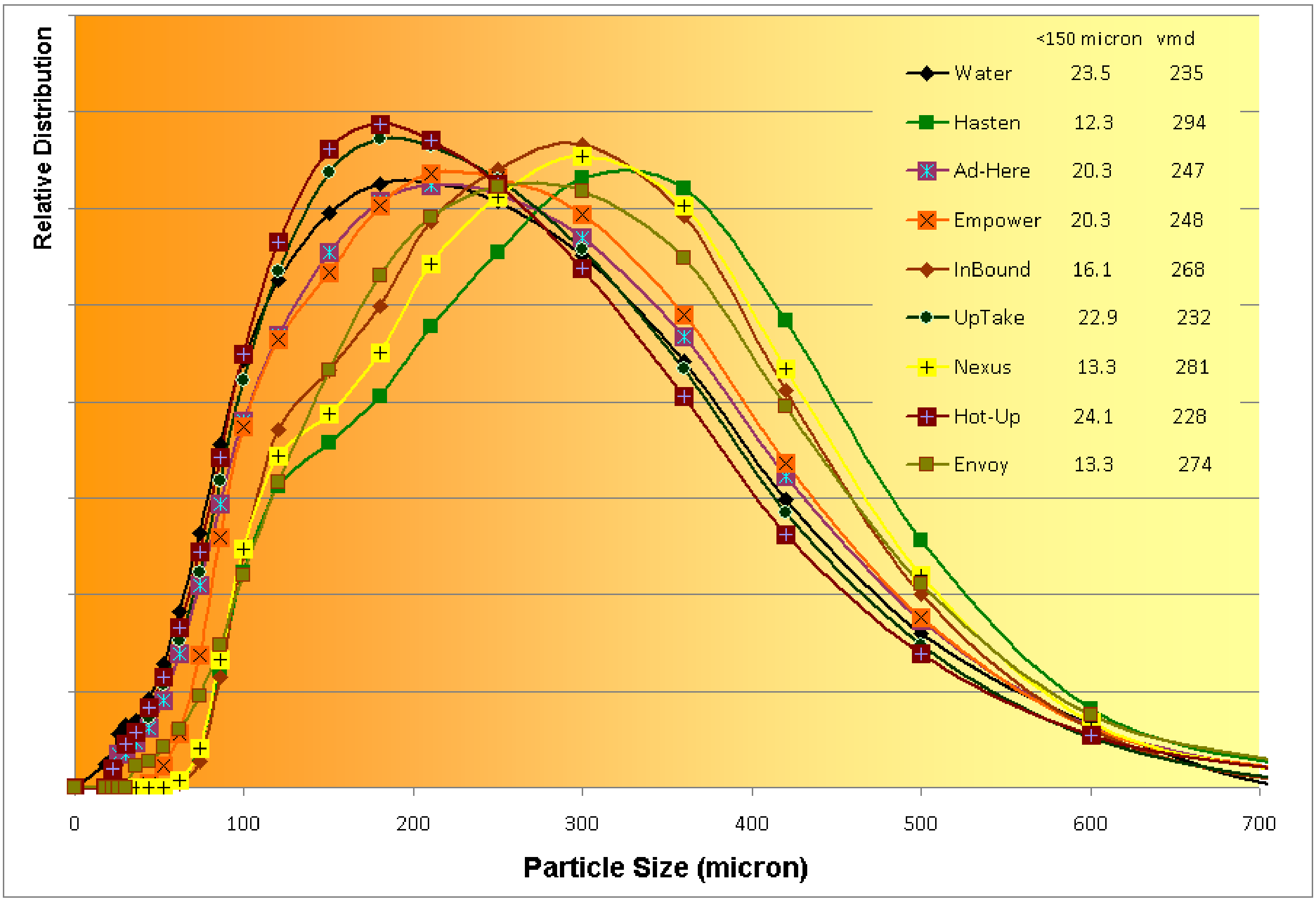
Effects from the Surfactants / emulsifiers: The higher the proportion of surfactants / emulsifiers in the product, the smaller the average droplet size. For the mineral oil products, Hot-Up has the highest proportion of surfactants and results in the lowest vmd especially when compared with Ad-Here and Empower which have much lower proportion of surfactants. The type of surfactants influenced the effects. InBound has similar proportion of surfactants to Uptake but produces a markedly higher vmd. InBound's surfactants closely match Deluge 1000 whilst UpTake most closely resemble BS1000. BS1000 was shown in Studies 1 & 2 to produce lower vmd than Deluge 1000. The proportion of surfactants in Hasten, Nexus and Envoy varies significantly without having a marked effect on the vmd. This may indicate that vegetable oils override the surfactant effects.

Adjuvant Effect on Spray Droplets

Peter Jones

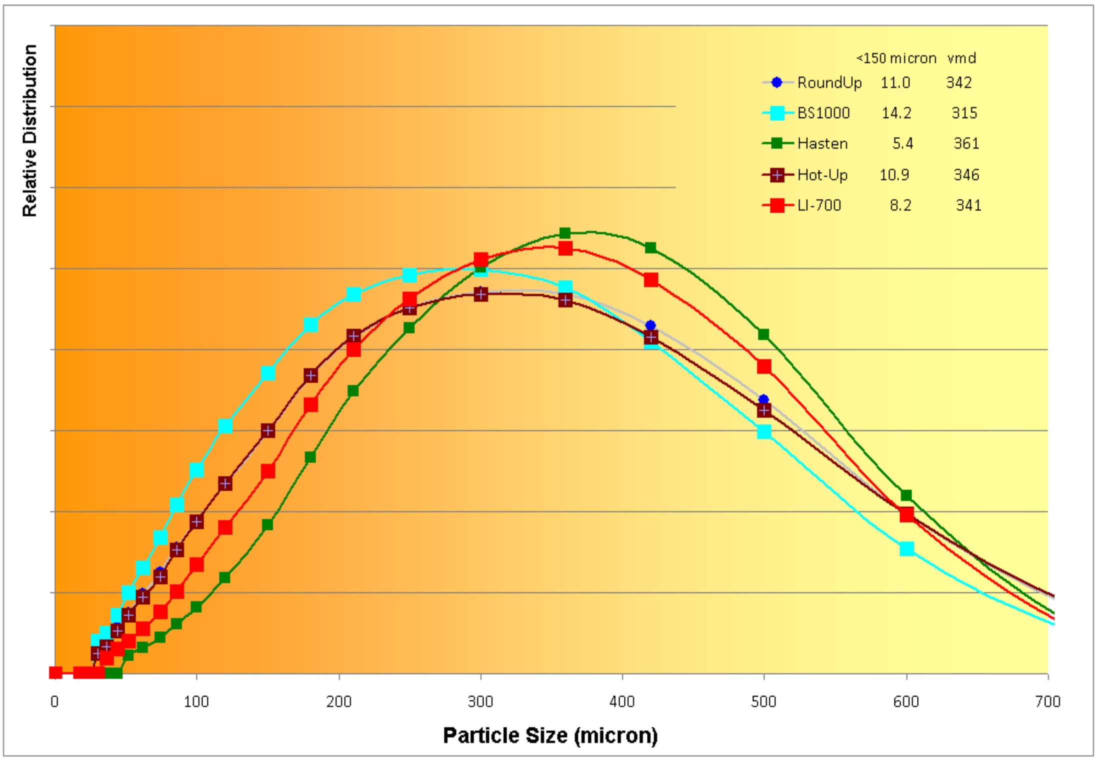
Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

FIGURE 4: Particle Size distribution for oil based adjuvants in water through XR11002 nozzle at 2.5 bar



Other Nozzles - AIXR11002 & TT11002

FIGURE 5: Particle Size distribution for adjuvants with RoundUp CT (2.5%) through AIXR11002 nozzle at 5 bar pressure



AIXR11002 – Air Induction Flat Fan

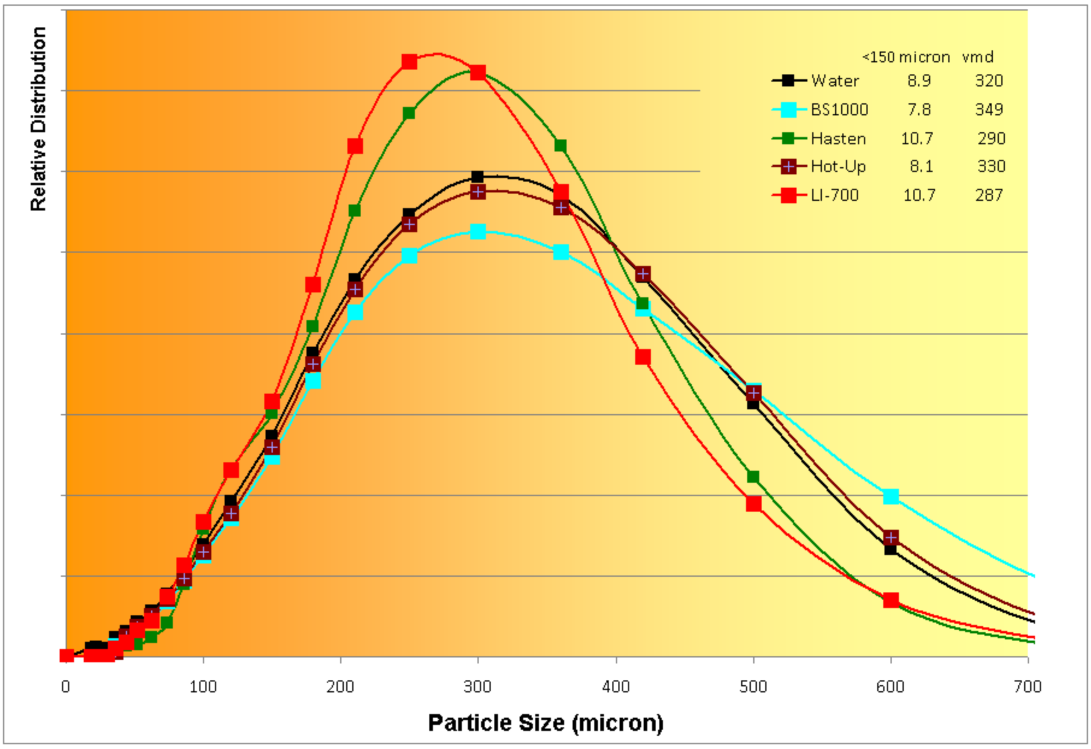
Whilst droplet size is much larger than for the equivalent size XR nozzle, the effect of the adjuvant is essentially the same. i.e. The results shown in Figure 5 show that wetting agents tended to reduce droplet size whilst oils based adjuvants increased droplet size. This effect is somewhat unexpected as the effect of air inclusion (essentially making a foam) would be expected to be promoted by wetting agents but suppressed by oils.

Adjuvant Effect on Spray Droplets

Peter Jones

Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

FIGURE 6: Particle Size distribution for adjuvants in water through TT11002 nozzle at 2.5 bar pressure



TT11002 Turbo TeeJet

Adjuvants appear to have the opposite effect on the Turbo Teejet nozzle TT11002. i.e. wetting agents increase droplet size whilst oils reduce. This effect is strongest for the larger particles. Whilst the 2 oil type products LI700 and Hasten produce only slightly more fines (<150 micron) than the wetting agents, the wetting agents tend to produce about double the amount of particles

General Discussion – Spray Drift:

Spray drift is a topic of increasing importance when considering pesticide spraying applications. Avoiding the formation of very small droplets (nominally <150 micron) is one way of reducing the risks of spray drift. Each of the graphs shown in Figures 1 – 6 show the proportion of the spray which is <150 micron (an arbitrary but commonly used definition of small driftable droplets or fines) and significant differences are apparent ranging from 5.4% of the spray volume (Hasten AIXR Figure 6) to 37.0% of the spray volume (BS1000 XR, Figure 3). Whilst each of the graphs represents a different spray application they all use 02 size nozzles and the pressure for the XR nozzles in Figures 1 – 4 varies only from 2 to 2.5 bar. The proportion of droplets <150 micron can vary by up to a factor of 3 by varying adjuvant product. In Figure 1, Hasten or LI 700 produce less than one third the volume of fines (<150 micron) than does BS1000 and when tank mixed with RoundUp CT, the choice of adjuvant can have a twofold difference in the proportion of fines (eg Figure 2 Hasten vs BS1000)

Clearly the choice of nozzle type and size and operating pressure has the most significant effect on the proportion of fines resulting from a spray application but the use of adjuvants will have a noticeable effect which should be considered.

Other operating parameters such as release height (boom height), vehicle speed, wind speed and direction, temperature and humidity and the nature of the spray area and its surrounds must be considered when spraying as they all play a role in how effectively a spray application is applied to a field and what risks it poses to neighbouring areas.

Peter Jones
Victorian Chemical Company Pty. Ltd., 83 Maffra St. Coolaroo Vic 3048 Australia

TABLE 1: Details of Products evaluated in the trials

Product Name	Active Constituent (s) / Type	Dilution Rate	Supplier
BS1000* Bio-degradable surfactant	1000 g/L Alcohol Alkoxylate (nonionic surfactant)	0.1 – 0.25%	Cropcare Australasia
Deluge† 1000 Wetting Agent	950 g/L Non-ionic Fatty Acid Ethoxylates (nonionic surfactant)	0.1 – 0.25%	Victorian Chemical Co
Hasten† Spray Adjuvant	704 g/L Ethyl and Methyl Esters of Vegetable Oil with 196 g/L Non-ionic Surfactants	0.5 – 1.0%	Victorian Chemical Co
Hot-Up† Spray Adjuvant	340 g/L Non-ionic Surfactant Blend 190 g/L Mineral Oil 140 g/L Ammonium Sulphate	0.25 – 1.0%	Victorian Chemical Co
Nufarm LI700* surfactant	350 g/L Soyal Phospholipids 350 g/L Propionic Acid	0.1 – 0.25%	Nufarm
Nexus† Spray Adjuvant	865 g/L Canola Oil	0.5 – 1.0%	Victorian Chemical Co
Sprinta† Superwetter	1020 g/L Polyether Modified Polysiloxane Organosilicone surfactant	0.1 – 0.25%	Victorian Chemical Co
Envoy† Spray Adjuvant	467 g/L Canola Oil 280 g/L Non-ionic Fatty Acid Ethoxylates 137 g/L Cationic Fatty Amine Buffering Salt	0.25 – 1.0%	Victorian Chemical Co
Spreadwet* 600 Wetting Agent	600 g/L Ethoxylated Nonylphenol & Alkyl Ether & Fatty Acids (nonionic surfactant)	0.1 – 0.25%	SST Australia
Ad-Here† Spray Adjuvant	970 mL/L Mineral Oil	0.5 – 1.0%	Victorian Chemical Co
Empower† Spray Adjuvant	861 g/L Petroleum Oil (mineral oil)	0.5 – 1.0%	Victorian Chemical Co
Wet-AS† Spray Adjuvant		0.1 – 0.25%	Victorian Chemical Co
InBound† Spray Adjuvant	653 g/L Paraffinic Oil (mineral oil) 217 g/L Non-ionic Fatty Acid Ethoxylates (nonionic surfactant)	0.5 – 1.0%	Victorian Chemical Co
Uptake* Spraying Oil	582 g/L Paraffinic Oil (mineral oil) 240 g/L Alkoxylated Alcohol (non-ionic surfactant)	0.5 – 1.0%	Dow Agrosciences
RoundUp* CT Broadacre Herbicide by Monsanto	450 g/L Glyphosate present as the Isopropylamine Salt	2.5 – 3.0%	Nufarm

* Third Party Trademark
† Trademark used under licence

The data generated for this document was obtained at University of Queensland, Gatton Campus with nozzles supplied by TeeJet Technologies both of whom we acknowledge for their expertise and assistance.