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Classification criteria for Fog and Mist application of pesticides.

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Summary

A rotary atomiser operated at 17,000 rpm with a flow rate of 35ml/min is proposed as a reference nozzle to differentiate between the spray spectra produced by mist and fog application equipment.

Key words: spray classification, reference nozzle, fog, mist, rotary atomiser

Introduction

With concern about downwind movement of agricultural spray droplets, a scheme was devised to quantify the risk by indicating the quality of the spray in relation to the proportion of droplets in different size classes. Spray from sample hydraulic nozzles was examined with different measuring instruments (Arnold 1987) and in view of the differences in the data obtained, the BCPC Spray Quality Scheme used reference nozzles to differentiate between droplet distributions of hydraulic nozzles (Doble et al 1985). This scheme was subsequently amended (Southcombe *et al* 1997) so that there are reference nozzles to indicate the boundaries between fine and medium, medium and coarse and coarse and very coarse categories, instead of having a reference nozzle giving a typical droplet spectrum for the spray quality. The scheme does not cover variations in spray quality within the 'very fine' spray quality, which is used inside buildings such as glasshouses. The application of very small droplets can pose an inhalation hazard so a new reference nozzle was required to differentiate between the main types of space treatment equipment used in glasshouses.

The two main types of equipment used in space spraying are generally referred to as foggers and misters. Foggers can also be classified as thermal (hot) and cold foggers. According to the WHO (Anon 1964) fogs (referred to as aerosols) had a volume median diameter (VMD) <50µm while a mist had a VMD between 50 – 100µm. In selecting a new reference nozzle to differentiate between a fog and mist, it was also considered that the demarcation should be extended to include the proportion of droplets below 30 µm. This size was selected as a high proportion of droplets smaller than 30µm would require the user to wear a respirator, although it is droplets smaller than 10µm, that are most likely to be inhaled (Clay and Clarke (1987).

Measurements.

Droplet size spectra were measured with a Malvern[1] 2600 particle size analyser. The instrument was fitted with a 800 mm lens and each reading comprised of 1000 scans (equivalent to sub samples). Nozzles were directed horizontally and positioned approximately 350 mm in front of the beam. A 400 mm axial fan situated at the rear of the apparatus withdrew spray away from the sampling area (in order to minimise operator exposure to spray and prevent small droplets re-circulating in the beam); the air flow passing across the laser beam was approximately 2 $m.s^{-1}$ .at the beam. A background reading was taken after sampling and, in order to compensate for aberrations caused by engine heat from the electrically operated cold fogger nozzles, the 'kill-data' function was used to immobilise the 2 inner rings of the Malvern detector. Numbers were exported electronically into a data-base in the form of cumulative volume distributions over 32 size classes. Measurements were repeated at least once on a separate occasion to check for consistency.

A spinning disc ('Ulva+' – Micron Sprayers, Bromyard, UK) positioned 15 cm from a Malvern 2600 Particle Size analyser was operated at different voltages applying water plus 0.01% surfactant through a yellow restrictor (Flow rate 35ml/min.). Subsequently similar data was obtained using two electrically operated cold foggers (ULV 'E2', - Microgen, San Antonio, USA and 'Starlet' ULV, - Motan, Isny, Germany) and a air-assisted spinning disc sprayer ('Ulvafan' – Micron Sprayers Bromyard, UK) operated at two flow rates, 35 and 144ml/min.

Results

VMDs are presented in Fig. 1 as points from which a regression line has been calculated using a Microsoft 'Excel' spreadsheet power function. The relative span[2] and percentage of spray by volume below 30µm., obtained using the 'Ulva+' disc at different voltages, are also shown in Fig. 1.

A VMD of 50µm was obtained at approximately 20 volts when the disc speed was 17000 rpm (Fig. 2). At voltages above 17 volts up to 10 per cent by volume is below 30µm. The span was not significantly affected by the voltage over the range tested.

The droplet spectra of two 'cold foggers' and the 'Ulvafan' at two flow rates are indicated in Fig. 3 in comparison with the data for the 'Ulva+' at 17,000 rpm. Both cold foggers applying an aqueous spray had a VMD <50µm and the volume of spray below 30µm exceeded 35 per cent. The 'Ulvafan' VMD exceeded 50µm but the volume of droplets<30µm was <5 per cent.

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[1] Malvern Instruments Ltd., Spring Lane South, Malvern, Worcs., WR14 1AT, UK

[2] $D_{[v,0.9]}$ minus the $D_{[v,0.1]}$ divided by the VMD ($D_{[v,0.5]}$)

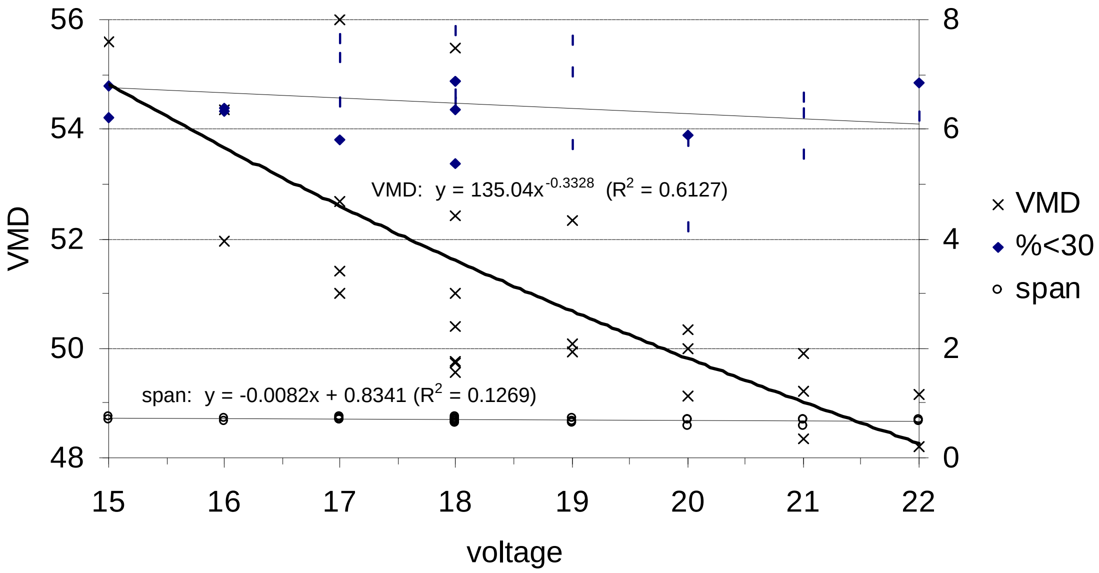

Fig. 1 Regressions for VMD and relative span for an Ulva+ loaded at 35 ml/min (yellow restrictor)

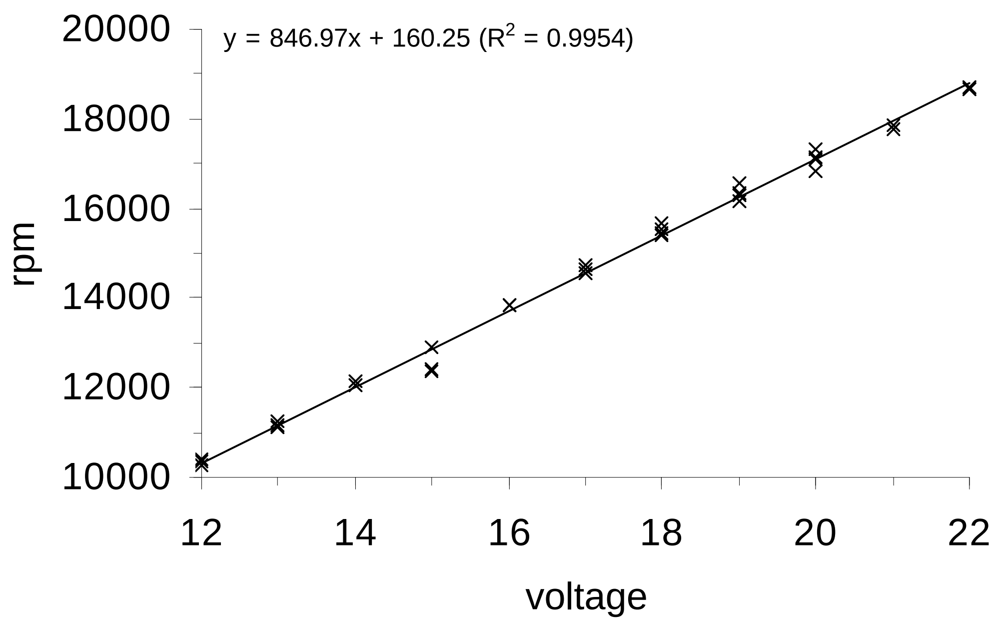

Fig. 2 Measured rotational speeds of an Ulva+ loaded at 35 ml/min (yellow restrictor)

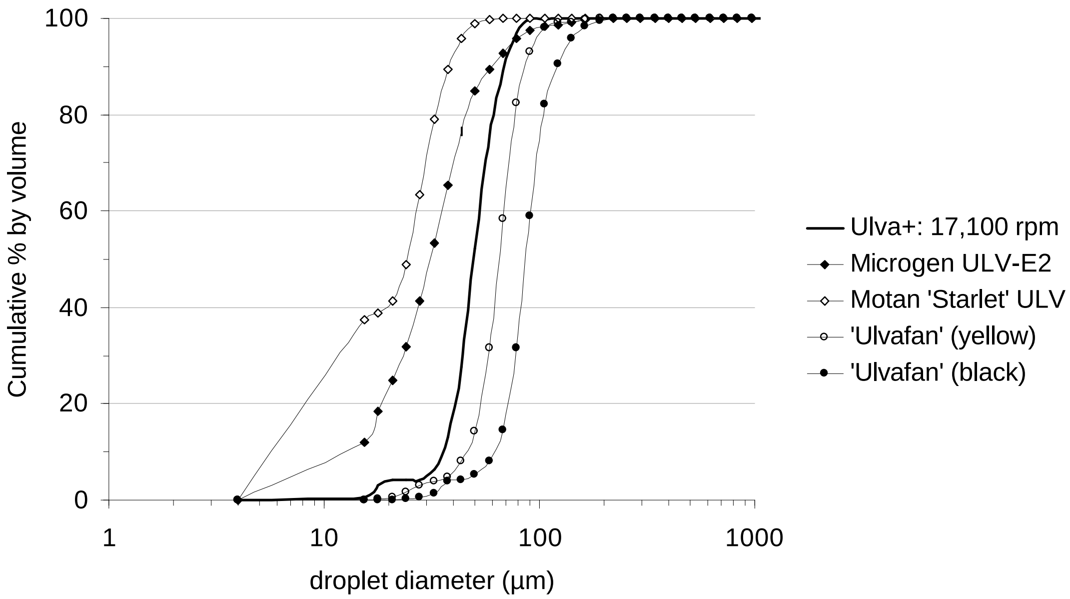

Fig. 3 Droplet spectra of two ‘cold foggers’ and the ‘Ulvafan’

Discussion

The Malvern analyser was used in preference to other laser type equipment as it samples the total spray output with a resolution to below 10µm. However in this study the 800mm lens was used to provide a larger sampling area within the beam. Several types of low volume mist categories of spray. In earlier experiments a very small orifice green cone ‘misting and fogging’ nozzle (Sprays International) operated at 11 bar (150ml/min) also gave a VMD of 50µm and provided data used in the ASAE reference categories (Fig 4) (Hewitt, personal communication). The use of a spinning disc overcomes the problem of using a high pressure and avoids a small orifice, which is very easily blocked.

When the 53 mm toothed and grooved spinning disc (Ulva+) is operated at 17000 rpm., it provides a suitable reference that in terms of Malvern Analyser data meets the following definitions :-

- A fog has a VMD < 50µm with > 10% by volume in droplets <30µm.
- A mist has a VMD > 50µm and < 10% by volume in droplets <30µm.

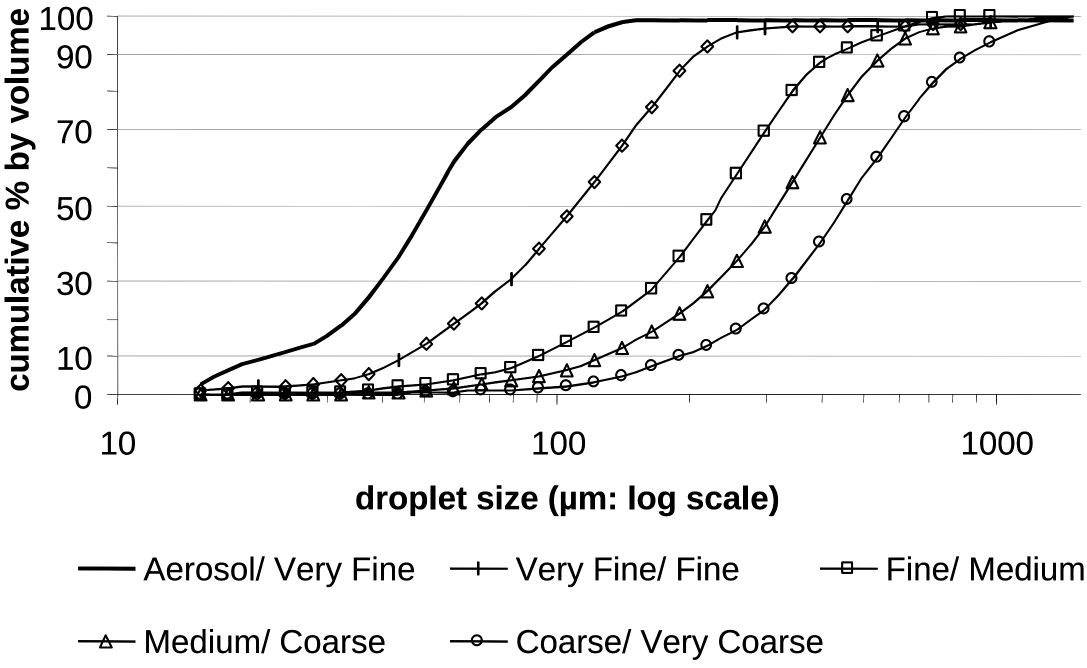

Fig. 4 Data used by ASAE based on measurements made at IPARC.

While droplets smaller than 10µm present the greatest inhalation hazard, there can be a risk of exposure to operators entering areas treated with a fog containing larger particles which shrink to below 10µm. Therefore a distinction between fogging and mist applicators should also include a criterion based on the volume of spray containing droplets smaller or larger than 30µm. The measurements reported here do allow a differentiation between the two types of pesticide application equipment used in glasshouses and in similar circumstances. However, the data does not provide a detailed measurement of the smallest inhalable droplets, so cannot measure potential inhalation exposure.

The VMD of cold foggers when applying an aqueous spray is higher than when using the more normal kerosene based or equivalent ULV formulation. Nevertheless the spray distribution is well below the proposed reference data for fogs.

Both fogs and mists are used in enclosed spaces so differentiation between a truly space treatment with fog and surface treatments with mists does require an easily used reference nozzle. When certain treatments are applied as a mist, it is unlikely to present an inhalation risk, whereas a fog has a potential inhalation risk, which needs to be assessed for actual operating conditions.

Using a spinning disc reference nozzle here is more appropriate than the more usual hydraulic nozzles as it is necessary to minimise the proportion of inhalable droplets applied with mists in contrast to the spectra obtained with foggers.

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