Sprayer Evaluation and Droplet Size Measurements at IPARC: hydraulic atomisers

Procedures

Spray measurement procedures have been adapted from the original BCPC protocols – which can be found on: http://www.dropdata.net/bcpc_ewg. These protocols are the product of a collaborative network, first described by Doble *et al*. (1985), and followed by a subsequent "narrative" on UK thinking about spray classification: described in a number of papers including Southcombe *et al*. (1997) and Miller *et al*. (2002). From the early days, it was agreed that, rather than emphasising droplet size statistics which can be affected by methods of measurement, readings should also be compared with a set of measurements taken with reference nozzles. Some reference curves recently obtained in IPARC are shown in Appendix 1 (these and others are published on our website).

In-flight analysis of spray droplet spectra at IPARC has carried out with a series of Malvern[1] particle size analysers (PSA). Nozzles are normally positioned approximately 300 mm in front of the laser beam with spray sampled as in the original BCPC protocol, which suggests nozzle positions relative to the laser beam as follows:

Flat Fan Nozzles:

- A - Short axis, centre-line, 300 mm from tip.
- B - Short axis, 25 mm from detectable edge, 300 mm from tip.
- C - Long axis, 120 mm from tip.
  (Flat fan positions B & C are optional)

Hollow Cone Nozzles:

Centre-line, 120 mm from tip; if possible rotate through 360º during sampling.

A standard procedure with the Malvern 2600 long-bed instrument has been to position the beam at a slight angle to the plane of spray, so that it enters just below one edge and out through the other. With very wide angles of spray it is not possible to follow this procedure without contaminating the lenses. For the 110º fan nozzles readings were obtained by holding the nozzle nearer (approximately 150 mm) to the beam. When this practice was evaluated by Combellack and Matthews (1981), there was little difference in VMD with sprays created at <500 kPa, with measurements made at different distances from the beam (over the 50 – 300 mm range).

The procedure above is not possible with 'Spraytec' droplet size analyser, which is limited to a working gap of some 500 mm. Quick measurements therefore take place at position 'A', or a more through investigation takes place by repeated measurements when a spray fan is vectored across the beam. Malvern provide technical notes on the averaging methods used.

A 400 mm axial fan, situated at the rear of the apparatus, withdraws spray away from the sampling area at a nominal 1 $m.s^{-1}$ (in order to minimise operator exposure to spray and prevent small droplets re-circulating in the beam).

Spray mixture from a 'Cornelius' tank is propelled to the nozzle with a pressure-regulated air line. Nozzle pressures are checked with a meter (Bundenberg: accurate to 10 kPa) connected

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

with a ‘T-piece’ adjacent to the nozzle body. Until 2007, all spray output measurements were with tap water with 0.1% Agral 90, (a standard surfactant used for spray nozzle evaluation, *e.g.* Arnold, 1983) this has a surface tension more similar to pesticidal mixtures than water alone. The withdrawal of Agral in the EU raises an issue over the BCPC protocol (see Appendix 2).

Instruments for droplet size measurement

Recent droplet size spectrum measurements have been carried out using two instruments:

The older Malvern 2600 long-bed instrument was usually fitted with an 800 mm lens for measuring hydraulic atomisers, giving accurate droplet size measurement in the 15.5 - 1503 μm range. Each reading comprised of 1000 scans (equivalent to sub samples). Measurements were repeated at least once on a separate occasion to check for consistency and are presented here as Malvern output. Numbers were exported electronically into data-base in the form of cumulative volume distributions over 32 size classes and are available electronically in ‘Excel’ spreadsheet format.

Droplet size spectra for hydraulic atomisers are now obtained with a ‘Spraytec ’97’ droplet size analyser, which uses a Laser with a wavelength of 670 nm, fitted with a 450 mm lens; unless stated otherwise all 31 scattering rings are used. Software for processing is Insitec RTSizer for Windows with time history; calibration overlays used are: ST45AIWA.CAL, STAESFSE.IMG, STD0515.RSP. As previously, droplet/particle size distributions are given in volume fraction format, with 60 size classes as output.

Sample nozzles that have been tested for calibration or contract work are retained for further validation if required. The BCPC protocol suggests that data can be summarised using the VMD, D[v,0.1] and D[v,0.9], but in our experience the use of just these three points can introduce considerable inaccuracies for modelling work, so data for the whole spectra are always retained. We have found that log-logit regression from ‘Model independent’ data obtained with hydraulic nozzles almost always gives a close fit, with R^2 values of >0.95; where there is a deviation of observed values from the regression line, an artefact (such as insufficient focal length of lens) can often be found.

References

Arnold, A C. (1983) Comparative droplet-size spectra for three different-angled flat fan nozzles. *Crop Protection*, **2**: 193-204.

Bateman R P, Matthews G A, Bals T E, Hewitt A J (2006) The BCPC nozzle classification scheme: progress, protocols and international promotion. *Aspects of Applied Biology*, **77**: 43-50.

Butler Ellis M C, Tuck C R, Miller P C H. (2001) How surface tension of surfactant solutions influences the characteristics of sprays produced by hydraulic nozzles for pesticide application. *Colloids and Surfaces A: Physiochemical and Engineering Aspects* **180:** 267-276.

Combellack J H, Matthews GA. (1981) Droplet spectra measurements of fan and cone atomisers using a laser diffraction technique. *Journal of Aerosol Science* **12:** 529-540.

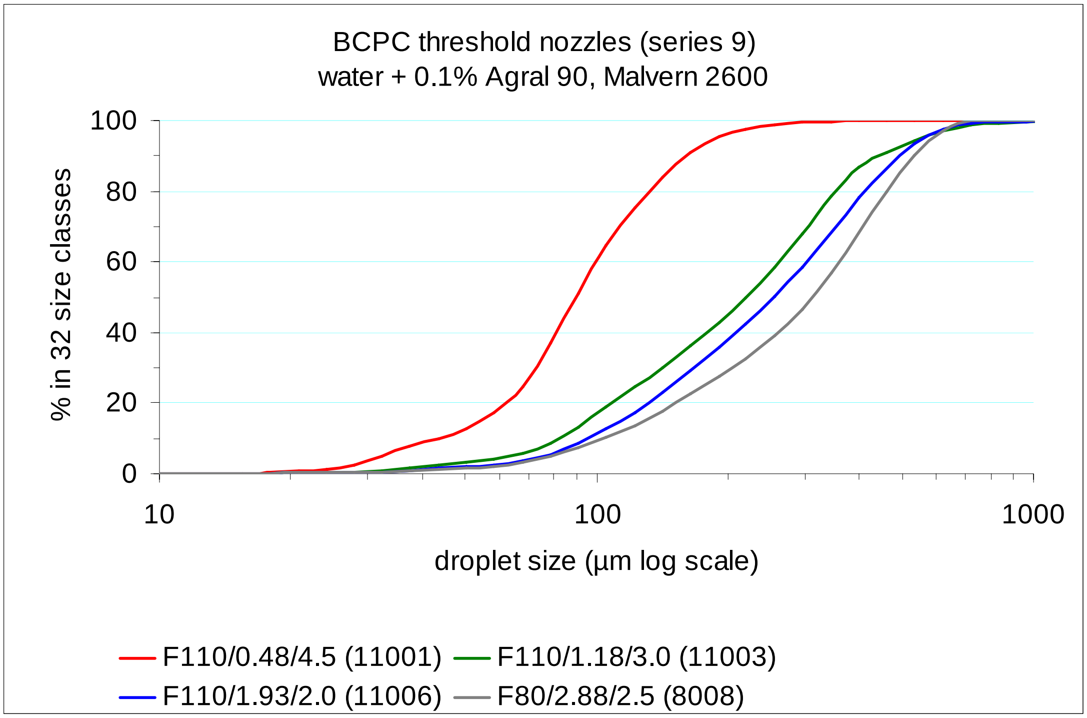
Doble S J, Matthews G A, Rutherford I, Southcombe E S E (1985). A system for classifying hydraulic and other atomisers into categories of spray quality. *Proceedings British Crop Protection Conference - Weeds*, 1125-1133.

Miller P C H, Butler Ellis M C, Gilbert A J. (2002) Extending the International BCPC spray classification scheme. *Aspects of Applied Biology*, **66**, 17-24.

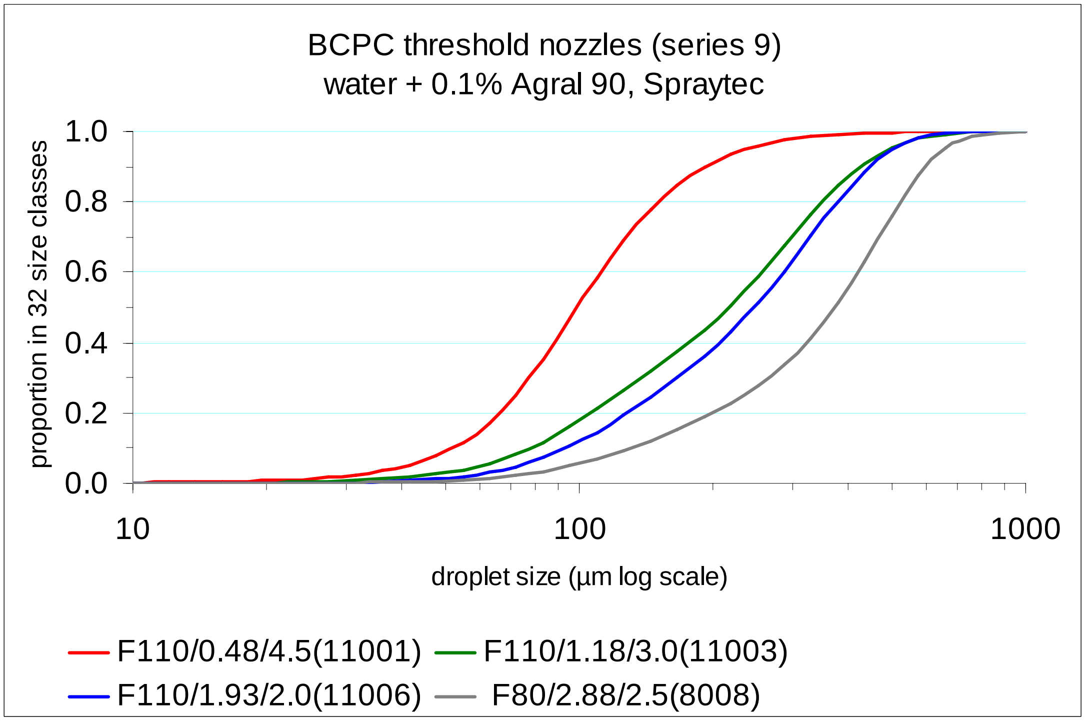
Southcombe E S E, Miller P C H, Ganzelmeier H, Miralles A, Hewitt A J. (1997) The international (BCPC) spray classification system including a drift potential factor. *Proc Brighton Crop Protection Conference* 371-380.

Appendix 1

Calibration curves for BCPC reference nozzles (threshold set No. 9)



A. Malvern 2600C long-bed instrument, fitted with an 800 mm lens



B. 'Spraytec' particle size analyser, fitted with a 450 mm lens

Appendix 2

Observations on "standard" spray liquids

Butler Ellis *et al*. (2001) described how various surfactant solutions can reduce the droplet size spectra of sprays produced by hydraulic sheet break up (with flat fan and cone nozzles) in comparison with water alone. The protocols for spray droplet measurements used in the BCPC spray classification scheme are based on the use of water + 0.1% Agral 90™ (a nonyl phenyl ethoxylate adjuvant). In the UK (although not in the USA or Germany where plain water is often used) we have held the view that this should be a 'standard' for measurements since pure water is atypical of spray tank mixtures. However, Agral was not re-registered at the end of 2004 (together with a number of other alkyl phenyl ethoxylates [APE] withdrawn in the same EU directive) and is now no longer available. Bateman *et al*. (2006) discussed the updating of BCPC protocols, and argued that the technical requirements of a replacement surfactant would include:

- as low toxicity as possible; the replacement should NOT be a different APE;
- consistent, standard chemistry;
- as similar as possible in atomisation characteristics to Agral - to give 'backward compatibility' with existing work.

The droplet size analyses of three characteristic nozzles with three spray liquids is part of a study that showed that 0.1% Agral 90 does appear to reduce droplet size in comparison with plain water (and another test fluid containing 0.5% industrial methylated spirit).