A SYSTEM FOR CLASSIFYING HYDRAULIC NOZZLES AND OTHER ATOMISERS INTO CATEGORIES OF SPRAY QUALITY

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ABSTRACT

A spray classification system is proposed which divides the quality of spray produced by hydraulic nozzles and other atomisers into five categories. The system provides a simple, pragmatic method for relating the spray quality produced by different sizes and types of nozzles operated at different pressures. It enables advisers, users, product suppliers and registration authorities to describe the preferred way in which the product should be presented to the target and to determine the environmental safety of the proposed application.

Differences have been found between the cumulative volume curves produced by different droplet measuring systems for a given nozzle operated at a given pressure. When sprays are ranked in order of fineness, the order needs to remain the same for each measuring system. For this reason, spray qualities are classified by reference to standard nozzles representative of each category. BCPCwill approve droplet measuring systems, on which the cumulative volume curves for reference and test nozzles can be compared.

A nozzle description code is also proposed which details the nozzle type, spray angle, output and rated pressure.

INTRODUCTION

There is a need for the quality of spray produced by a nozzle to be easily and simply described. This would allow a better understanding of the likely effect on both efficacy of application and safety of using different sizes and types of nozzles at different pressures. (Elliot and Wilson 1983).

It is possible to measure the droplet size spectrum of a spray using a variety of measuring systems. The results are usually presented as a cumulative volume curve which shows the volume of spray contained in a range of size classes represented by an average droplet diameter.

This curve adequately describes the range of droplets produced in a spray. However, attempts to reduce the curve to a single figure introduce inaccuracies. For example, the Volume Median Diameter (VMD) describes the droplet size above which, and below which, equal volumes of spray are contained. However, it takes no account of the shape of the curve. Two sprays with equal VMD figures could have very different numbers of driftable droplets and very large droplets.

The term "span" produces a single figure which encompasses the droplet size below which 90%, 50% and 10% of the spray volume is contained. (Span $= \frac{90\% \text{ diameter} - 10\% \text{ diameter}}{50\% \text{ diameter}}$). Again, this does not take full account of the shape of the curve.

These difficulties lead to the proposal to classify spray droplet spectra into five categories based on their whole cumulative volume curve between the 10% and 90% limits. (See "Definition of spray categories")

The pesticide user is often making a considerable investment in the products and spraying equipment, but is not always given detailed advice on the best type of spray to use. He is normally only informed of the dose and volume rates. The ability to describe a preferred spray quality, at any volume rate, will enable advisers, users, product suppliers and registration authorities to describe the preferred way in which the product is presented to the target and to determine the environmental safety of the proposed application.

It is accepted that for some products, precise spray quality recommendations will never be determined due to the flexibility and tolerance of the product and the complex nature of the crop or target. However, there have been examples of products where good evidence has been obtained to indicate that a particular spray quality is biologically or environmentally desirable or, conversely, undesirable. In these cases, phrases have appeared on labels attempting to inform the user - by specifying a minimum pressure, by recommending the actual nozzles to be used or by warning of drift or other hazards.

There has long been a tacit acceptance by product suppliers and registration authorities that most sprayers used for general arable spraying conform to a traditional standard using nozzles based on well known designs operating within reasonable limits of pressure and speed. This standard has performed adequately and safely and is universal, representing vast numbers of essentially identical sprayers. It is this standard which BCPC has adopted as the basis for the proposed spray classification.

This paper describes the system for classifying sprays and the use of that system. A handbook will be published by BCPC which will classify the sprays produced by nozzles and enable users to select and use nozzles to obtain the best spray quality for a particular situation.

BCPC SPRAY CLASSIFICATION

A number of spray classifications exist, but are not directly relevant to UK agriculture and horticulture nor to hydraulic nozzles. The relationship between droplet size, the number of droplets and volume rate has been discussed in many papers. (Matthews 1979).

The BCPC classification uses five simple, familiar, descriptive terms to describe the spray categories. They are: VERY FINE; FINE; MEDIUM; COARSE and VERY COARSE.

An important feature of the classification system is the ability to compare directly the spray spectra produced by different types and sizes of nozzle used at different pressures. Any category will, therefore, contain a mixture of flat fan, hollow cone, and other types of nozzle which, when operated at different pressures, produce very similar spray spectra.

Spray Categories

MEDIUM is the reference category. It is based on the spray produced by nozzles used in current general arable spraying - traditionally accepted by product suppliers and registration authorities. In general, this would coincide with volume rates from 200 litres per hectare to 330 litres per hectare at 2 to 3 bar pressure, normal speeds and nozzle spacing.

Other nozzle types and pressures producing sprays of similar quality would be placed in this category.

The FINE category ranges down to the finest spray commonly used in arable spraying. Its finer limit is carefully defined to avoid spray qualities which might present serious drift hazards.

The COARSE category represents sprays which are coarser than those normally used for general arable spraying. They would often be used for application to soil surfaces.

The VERY FINE category is for exceptionally fine sprays which would only be used where very clear evidence can be demonstrated of the biological need and product safety.

The VERY COARSE category is for exceptionally coarse sprays. A typical use would be liquid fertiliser application to soil and would often be associated with very high volume rates.

Label recommendations

The BCPC classification provides a simple, pragmatic means of communicating via the label to the user, the form of spray in which to apply the product. Product suppliers, and others making formal recommendations for use of pesticides, will be asked to consider their knowledge and experience of the product and target to see if any evidence exists for specifying a spray category other than MEDIUM. Greater choice can be offered to the user, if appropriate, by specifying two categories - for example MEDIUM or COARSE.

The preferred spray category will be indicated on the label as a simple phrase. For example, "Apply as a MEDIUM spray (BCPC definition)". The user will be able to find out from BCPC information (to be produced), his sprayer or nozzle supplier, product supplier or adviser which nozzles and pressures conform to the category. He will be able to set his sprayer for maximum efficacy and safety.

Where a specific recommendation for optimum performance can be identified, this should be stated, usually by specifying the preferred nozzles and pressures to be used.

BCPC NOZZLE CODE

The BCPC nozzle code details the nozzle type, spray angle (if known), output and rated pressure. It does not indicate spray quality because nozzles with the same physical description do not necessarily produce the same spray quality. Small manufacturing differences and different materials may affect spray quality - particularly with hollow cone nozzles. Also, nozzles may move from one category to another depending on the operating pressure.

The code has been developed to allow particular nozzles to be specified or described without using manufacturer's individual codes or terminology. The main use of the code will be to describe nozzles in a standard format so that they can be compared directly with each other and with manufacturers codes. For this reason, a standard rated pressure should always be used - 3.0 bar for normal hydraulic nozzle and 1.0 bar for low pressure nozzles. For specific purposes, where operating pressure is a critical factor, the pressure and the corresponding output may be stated.

Table 1

TYPE	SPRAY ANGLE	NOZZLE OUTPUT	RATE PRESSURE
Flat fan (F) (Note a)	Degrees (°)	) litres per minute	) (Note a)
Hollow cone (HC)	(Note b)	) litres per minute	) (Note a)
Deflector (D)	(Note b)	) litres per minute	(Note c)

Notes: (a) F = triangular deposit flat fan - rated at 3 bar.

FE = rectangular deposit flat fan ("evenspray") - rated at 3 bar.

FLP = low pressure flat fan - rated at 1 bar.

HC = hollow cone - rated at 3 bar.

(b) To be specified if known.

(c) Deflector (anvil) nozzle normally rated at 1 bar.

Examples:

BCPC NOZZLE CODE	DESCRIPTION	NOZZLE OUTPUT LITRES PER MINUTE	RATED PRESSURE bar
F110/1.6/3	110° Flat fan nozzle	1.60	3.0
HC69/0.47/3	Hollow cone nozzle	0.47	3.0
D –/2.4/1	Deflector nozzle	2.40	1.0
FE80/1.83/3	80° "Evenspray" fan nozzle	1.18	3.0
FLP80/0.79/1	80° low pressure fan nozzle	0.79	1.0

DEFINITION OF SPRAY CATEGORIES

In order to determine the relationship between the spray quality of different nozzles at different pressures, it is, as has been described, necessary to consider their complete droplet spectra, between the 10% and 90% points on their cumulative volume curves. Outside these points the data become prone to increasing errors.

Measurement of droplet spectrum

Measurement of spray droplet spectra has been the subject of much debate in recent years (Arnold 1983, Young 1985). No one method has yet been shown to give a totally complete answer, and cumulative volume curves produced by different methods vary markedly.

A BCPC exercise has been undertaken to study various methods of measuring droplet size, using selected standard nozzles which were circulated to several collaborators who operate different measuring equipment. Fig A shows that the measured spectra can vary by ± 40% as indicated by their VMD's. The highest figures result from computer image analyser measuring droplets as their impression captured on a suitable sampling surface - magnesium oxide coated glass slide for the Optomax and a viscous fluid for the Biotran colony counter. The lowest figures are given by the Malvern laser operated analysers which sample spray clouds in flight passing through a thin laser beam, but using different computing processes to quantify the spectra to the PMS laser analyser.

Footnote - Optomax - Analytical Measuring Systems Ltd, Shirehill Industrial Estate, Saffron Walden, Essex.
Biotran - New Brunswick Scientific Co Inc, 44 Talmadge Road, Edison, New Jersey, USA.

Even within one method, differences can occur. Figure B shows that the Malvern analyser gave a difference of ± 12% depending on the model, all being used to the same protocol.

All these methods are commonly used and highly developed, producing valid results. However, these data highlight the problems of quoting definitive figures for droplet spectra.

Spray classification

It has been necessary to devise a method for dividing the ranking order into the spray categories which allows the use of different, suitable droplet sizing methods.

Three reference nozzles have been selected to be characteristic of the three main categories (FINE, MEDIUM and COARSE), representing approximately the mid-point of the range of spectra encompassed by each category (see Table 2). The thresholds between each category are not intended to be precisely defined, allowing a small degree of flexibility for judgement in classifying nozzles whose spectrum coincides with the threshold.

The threshold between FINE and VERY FINE has been more precisely defined by use of a fourth reference nozzle, which produces a spray characteristic of the finest sprays normally used in arable crop protection.

The VERY COARSE category is defined as sprays which are significantly coarser than the reference COARSE spray droplet spectrum.

Method of use

Selected examples of the four reference nozzles will be made available by BCPC to collaborating laboratories operating particle size analysers approved by BCPC for this purpose. In use, a reference chart will be constructed for each analyser by plotting the cumulative volume curves for the four reference nozzles operated at a specified pressure, following a BCPC protocol for that analyser. Regions equidistant about the three reference curves will determine the category areas except for the FINE/VERY FINE threshold which is defined by the fourth reference curve.

Droplet diameters equivalent to the 10%, 50% and 90% cumulative volumes will be measured for each test nozzle and superimposed onto the reference chart. It will be necessary to repeat the procedure for each test nozzle at several pressures to determine whether it moves into another category as the pressure is changed. See figure C.

In Table 2, the four reference nozzles are detailed using the BCPC nozzle code (the final figure is the pressure at which the nozzle must be operated).

Footnote - PMS - Particle Measuring System Inc. 1855,S.57 Court, Boulder, Colorado USA.
Malvern - Malvern Instruments Ltd, Spring Lane, Malvern, Worcs.

TABLE 2

CATEGORY	BCPC REFERENCE NOZZLES	
VERY FINE		
		F110/0.45/4.5
FINE	F110/0.85/3.5	
MEDIUM	F110/1.44/2.5	
COARSE	F110/2.58/2.0	
VERY COARSE		

In table 3, further details of the reference and threshold nozzles are given. (Nozzle size, volume rate and droplet size data are purely representational).

TABLE 3

CATEGORY	NOZZLE SIZE (Note a)	PRESSURE (bar)	VOLUME RATE (litres/ hectare) (Note b)	DROPLET SIZE IN CUMULATIVE VOLUME (Note c)		
				10%	50%	90%
VERY FINE						
	01	4.5	82	35	85	195
FINE•	02	3.5	145	50	145	325
MEDIUM	04	2.5	250	70	235	450
COARSE	08	2.0	420	110	340	580
VERY COARSE						

Notes

a. Nozzle 'size' is as used by Lurmark, TeeJet, Delavan - for information only.

b. Volume rate calculated at 7 km/h, 0.5 m nozzle spacing.

c. Droplet size data based on averaged readings from a Malvern 2600 particle size analyser, 600 mm lens, laser beam passing through long axis of fan at 12 cm. Spray liquid - water plus 0.1% Agral.

DISCUSSION

The BCPC spray classification and the nozzle code are intended to form the basis for a common language when discussing and using hydraulic nozzles and the sprays they produce. This will facilitate the assessment and implementation of both the efficacy and environmental safety of any proposed method of application. Product suppliers, users and registration authorities and users will be able to communicate more accurately and simply than has been possible.

REFERENCES

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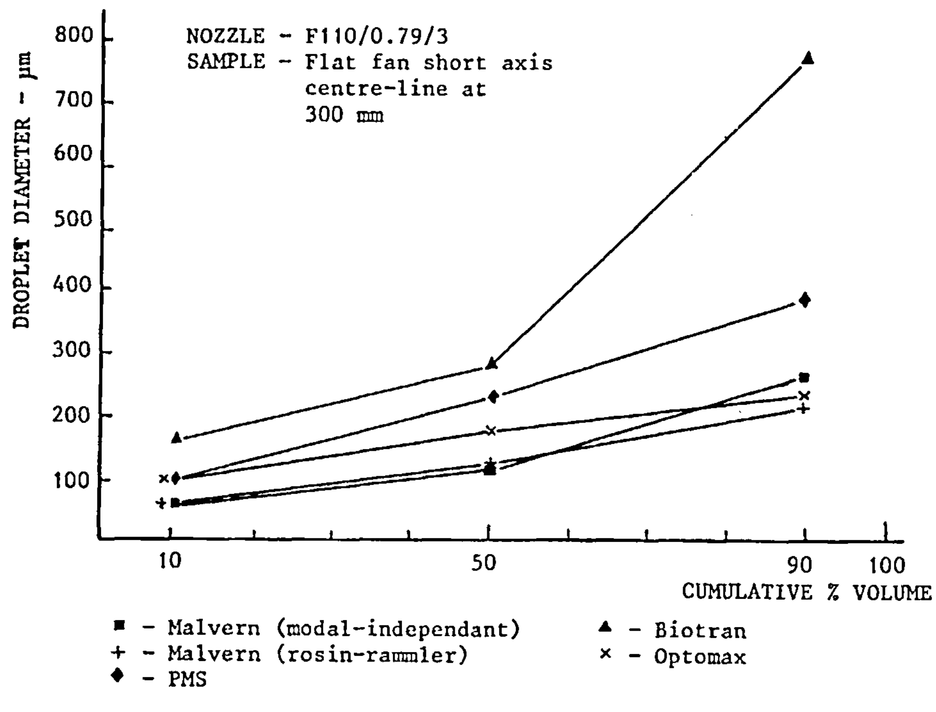

Figure A - Comparison of droplet sizing equipment.

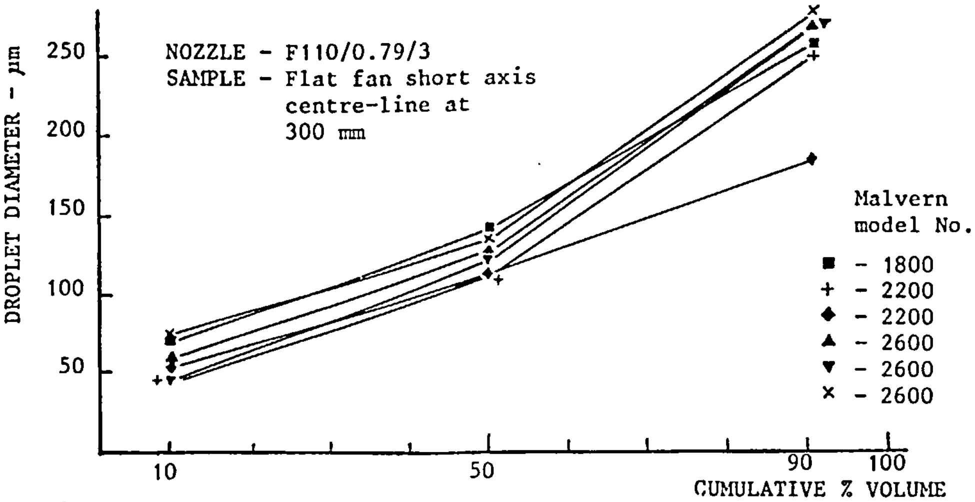

Figure B - Comparison of Malvern particle size analysers

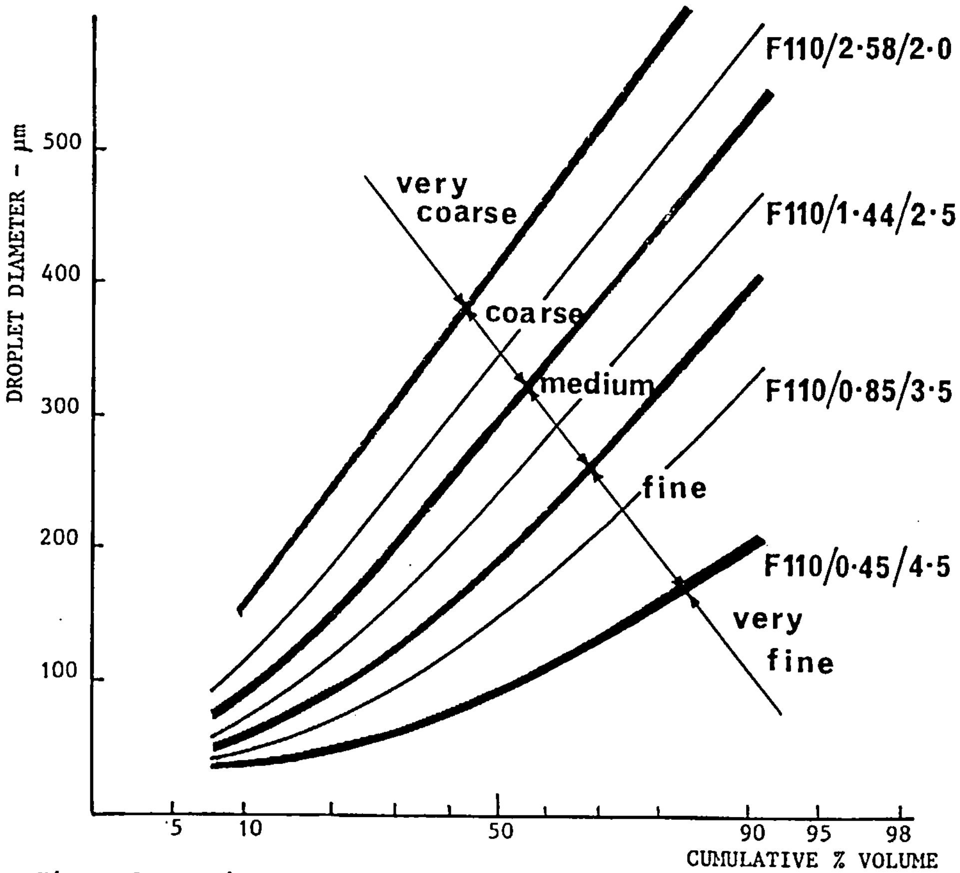

Figure C - Typical reference chart (for Malvern 2600 analyser)