A MEANS OF WINNOWING HYDRAULIC NOZZLES TO CONTROL DROPLET DRIFT

K.S. McKinlay
Research Station, Agriculture Canada
Saskatoon, Saskatchewan

R.J. Ford
Member CSAE
Research Station, Agriculture Canada
Saskatoon, Saskatchewan

W.K. Martin
Research Station, Agriculture Canada
Saskatoon, Saskatchewan

INTRODUCTION

The behavior of pesticide sprays is largely determined by droplet size. However, all commercially available spraying equipment produces droplets in a wide range of sizes and the presence of large numbers of small droplets in the spray can cause serious problems due to pesticides drifting out of the target area (1,2). One obvious solution to this problem would be to develop equipment that would produce homogeneous sprays of chosen drop sizes. Sprays of very uniform droplets can be produced by winnowed spinning discs (5, 9). Such devices are extremely useful for research purposes in the laboratory or field but their low flow rates, complexity, and cost make it seem unlikely that they will come into commercial use.

A number of other devices such as the Vibrajet (4), the Microfoil (3), and the vibrating boom (7), reduce drift by producing coarse sprays with reduced numbers of small droplets. Unfortunately, when large drops are used one must either increase the spray volume or accept reduced coverage.

A simpler solution to the drift problem would be to remove the small-drop component from the sprays produced by the ordinary hydraulic nozzles. Roth and Porterfield (8) reported results of preliminary tests in which a counter flow of air was used to remove small drops from the spray produced by a fan-jet nozzle. Similar experiments were carried out by Wiens and Bigsby (10). In both of these instances the movement of the air was directly opposed to the direction of movement of the spray droplets. Using a TeeJet 650067 nozzle at 35 psi (2.5 kg/cm^2), Wiens and Bigsby reported that the number of droplets below 100 μm were reduced from 20.5 to 7.5% by winnowing.

It was felt that the small drops might be removed more effectively if the winnowing airstream were at right angles to the fan of spray produced by the hydraulic nozzle. In such a system, an air curtain would be produced that could be penetrated by the more energetic large droplets but that would deflect the small droplets into a trap. The present paper reports the performance of such a system.

MATERIALS AND METHODS

The air curtain used in these tests was generated by a 0.234 X 15-cm slit cut in the side of a 5-cm tube maintained at an internal pressure of 5 cm of mercury. A trap consisting of a 25-cm^2 duct with a 7.5-cm inlet in one side (Figure 1) was located 10 cm from the slit. The lower lip of the trap inlet was tipped up to prevent drips forming and to ensure that all the spray collected ran into the trap. The nozzle to be tested was mounted 15 cm above the air curtain with the spray fan parallel to the trap inlet.

A 2% w/v aqueous solution of Uranine (sodium fluorescein) was supplied to the nozzle at a pressure of 2 kg/cm^2 from a pressurized reservoir. The spray was turned on and off by a fast-acting valve incorporated in the nozzle body. A pan under the assembly caught the spray so that it could be returned to the reservoir at the conclusion of each test.

Preliminary tests suggested that winnowing efficiency was improved if the air curtain was inclined upwards. With the equipment in use, problems were encountered if the inclination, θ (Figure 1) exceeded approximately 15° so this value was used for all succeeding tests.

The percentage of spray deflected into the trap at any given airflow could be varied by adjusting the horizontal separation between the axis of the spray fan and the lower lip of the trap. Tests showed that apparent elimination of the fine drops was accomplished when 7% of the nozzle output was deflected into the trap with little improvement as the capture rate was increased. Decrease in capture rate below this figure, however, resulted in the escape of considerable numbers of small drops. To leave some margin of safety, it was decided to conduct all subsequent tests with a capture rate of 10% of the nozzle output. The actual volume of liquid being caught was determined by cutting a drain hole in the bottom of the trap and measuring the flow from it after equilibrium had been reached.

The spray droplets were caught on a thin card (Mead Paper Co., Mark I Cover, 6 pt.) coated with a thin layer of gelatin. The relationship between drop diam and stain size for this combination of liquid and collecting surface was estimated by using a spinning disc (5) to produce homogeneous sprays in a wide range of sizes and comparing the diam of the stains produced with the equivalent drop-

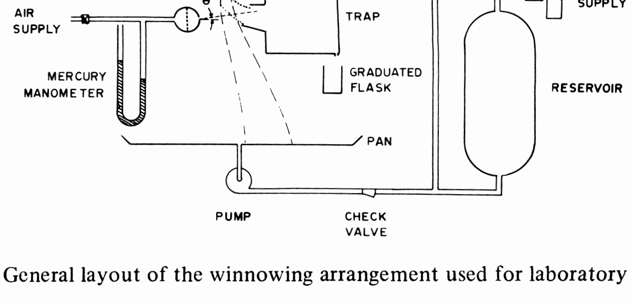

Figure 1. General layout of the winnowing arrangement used for laboratory studies.

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let diam as measured on magnesium oxide plates (6).

The sampling papers were placed in a box 12.5 X 10.0 X 7.5 cm with a 0.9 X 3.8-cm slit in the upper side to limit the amount of spray collected and to allow the small droplets to sediment out on the collecting paper under relatively still air conditions. The sampling box was traversed by hand through the entire area into which spray was falling at a point 45 cm below the nozzle.

Two nozzles, TeeJets 6501 and 650067, were each tested with and without winnowing on five separate occasions. On each occasion all droplets encountered while traversing the sampling paper were measured until a total of 100 had been accumulated. Thus the curves shown in Figures 2 and 3 were each based on a total of 500 measured droplets. All measurements of stain size were made with a microscope fitted with an image-shearing eyepiece.

RESULTS AND DISCUSSION

The drop spectra for the TeeJet nozzles are shown in Table I, and adjusted droplet-size distribution curves for the TeeJet 6501 and 650067, with and without winnowing, are shown in Figures 2 and 3, respectively. These curves have been scaled so that the top ends of the drop-size spectra, unaffected by winnowing, fit the same portion of the curve of the unwinnowed spectrum. In this way, it is possible to demonstrate the proportion of finer drops, by number, removed by winnowing (shaded area).

The operating conditions described above had been set up by trial and error so that 10% of the spray, by volume, would be carried into the trap as fine droplets by the winnowing air. The removal of this relatively small proportion of the spray had a very marked effect on the droplet spectrum of the spray that was released. The number median diameters for the 6501 and 650067 nozzles were 80 and 90 μm, respectively, without winnowing and rose to 240 and 212 μm with winnowing. The droplet spectra produced by the hydraulic nozzles alone contained very large numbers of small droplets that would be very prone to drift under field conditions. The percentages of droplets, by number, below 128 μm were 68 and 63%, respectively, for the 6501 and 650067 nozzles. When the winnowing airstream was used, these percentages fell to 5.6 and 9.5%.

These results suggest that, by following this approach, it should be possible to virtually eliminate droplet drift in field operations. At the present time, a field sprayer utilizing this method of drift control is under construction.

TABLE I DROP SPECTRA OF TEEJET 6501 AND 650067 WITH AND WITHOUT WINNOWING

	Percent by number (size range μm)					Percent by volume (size range μm)				
	Under 128	128 - 285	285 - 392	392 - 433	Over 433	Under 128	128 - 285	285 - 392	392 - 433	Over 433
6501										
Unwinnowed	68.0	23.4	4.8	1.6	2.2	3.3	33.3	26.6	13.9	22.9
Winnowed	5.6	61.0	20.4	10.0	3.6	.1	26.8	34.8	26.8	11.5
650067										
Unwinnowed	63.0	28.2	5.8	2.4	1.2	2.9	36.9	29.6	19.2	11.5
Winnowed	9.5	64.0	17.9	5.5	2.5	.2	34.4	37.5	18.1	9.8

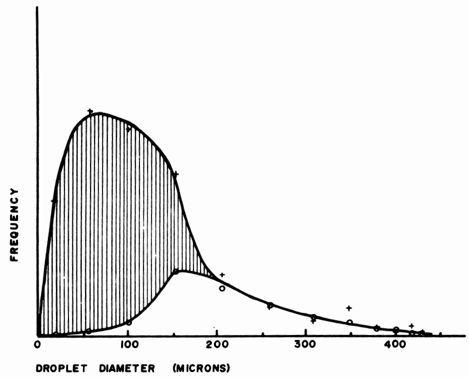

Figure 2. Droplet-size frequency distributions for the TeeJet 6501 nozzle with and without winnowing.

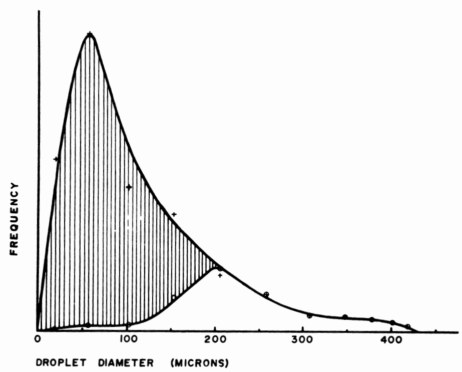

Figure 3. Droplet-size frequency distributions for the TeeJet 650067 nozzle with and without winnowing.

SUMMARY

The ordinary hydraulic spray nozzle produces droplets in a wide range of sizes including many below 100 microns that are apt to drift out of the target area. Homogeneous sprays in controlled drop sizes can be produced but the necessary equipment would probably be too expensive and complex for farm use. A simpler method would be to continue the use of hydraulic nozzles but remove all droplets below 100 microns.

It was found that a suitable air curtain and trap arrangement would reduce the percentages of drops below 100 microns from 60 to 4 or 5 percent by number.

REFERENCES

1. Courshee, R.J. 1959*a*. Investigations on spray drift. I. The small drop component of sprays. J. Agr. Eng. Res. 4: 144-152.
2. Courshee, R.J. 1959*b*. Investigations on spray drift. II. The occurrence of drift. J. Agr. Eng. Res. 4: 229-242.
3. Kirch, J.H., J.E. Waldrum and P.W. Bishop. 1969. The microfoil – an aerial device for controlling drift from conventional spry. Proc. 23rd N.E. Weed Control Conf.
4. Lake, J.R. 1970. Spray formation from vibrating jets. Brit. Crop. Prot. Counc. Monogr. No. 2.
5. McKinlay, K.S. and G.S. Glen. 1971. A shrouded spinning disc for the production of homogeneous sprays. Can. Agr. Eng. 13(1): 19-22.
6. May, K.R. 1950. Measurement of airborne droplets by the magnesium oxide method. J. Sci. Instr. 42: 500-501.
7. Reimer, C.A. 1964. Evaluation of a vibrating boom sprayer for drift control. Down Earth 20(1): 3-6.
8. Roth, L.O. and J.G. Porterfield. 1970. Spray drop size control. Trans. Amer. Soc. Agr. Eng. 13(6): 779-81, 784.
9. Smith, D.B., E.C. Burt and F.C. Benci. 1970. Design of a spinning disc, droplet separator and the determination of the size and density of droplets deposited on cotton foliage. Trans. Amer. Soc. Agr. Eng. 13(5): 664-668.
10. Wiens, E.H. and F.W. Bigsby. 1971. Winnowing as a means of removing small drops from a spray pattern. Can. Agr. Eng. 13(1): 13-18.