A SIMPLE CONVERSION OF A STANDARD PRECISION SPRAYER FOR LOGARITHMIC SPRAYING

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SUMMARY

A SIMPLE method is described for modifying an "Oxford Precision" sprayer so that it can be operated as a logarithmic concentration sprayer. The main feature of the modification is the provision of two chambers, and the use of an arrangement of jets for mixing automatically solutions passing through the concentrate chamber. Calibration tests show that the rate of decrease in concentration is logarithmic over the most useful part of the possible range. The modification is simple and inexpensive, contains no moving parts, and does not preclude its use as a simple precision sprayer for its original purpose.

INTRODUCTION

The principles and advantages of the logarithmic spraying technique have already been described by Hartley, Pfeiffer, and Brunskill (1956) and Fryer (1956).

Briefly, a logarithmic sprayer is a machine or equipment designed to carry out dilution continuously as the spraying proceeds, so that a wide range of concentrations can be applied in one operation.

The dilution principle is to supply the spray nozzles with liquid from an intermediate chamber which contains concentrate solution, but is also automatically replenished from another chamber which contains diluent. Provided the solution in the intermediate chamber is kept intimately mixed, this constant replacement results in dilution at a logarithmic rate.

The rates of chemical applied and volume per acre can be varied by changing the initial concentration, the jet size, the spraying pressure, or the speed of travel. The total range of concentration provided by the sprayer in one operation is determined by the ratio of the volume of the concentrate chamber to that of the diluent chamber. For the assessment of the potency of agricultural chemicals in the field, variation of dosage on a logarithmic scale is generally considered desirable.

MODIFICATION DESCRIBED

The standard sprayer used in these experiments was made by H. G. East & Co., Ltd., Oxford, England. It comprises a compressed air cylinder, a spray container ("Perspex" cylinder with metal ends), a handpiece, incorporated in which are a release valve and spraying-pressure gauge, and a spray boom, together with appropriate valves and tubing.

The modification was effected by dividing the spray container with a horizontal "Perspex" partition fitted with five rubber pipette-bottle teats (Fig. 1), each containing a number of fine slits placed so as to encourage even distribution and thorough mixing in the lower or concentrate chamber. These slits, totalling 44, allow flow to occur when pressure is applied to the upper chamber, and the outlet valve is opened, but no transference occurs when pressures are equalised.

The partition was constructed from $\frac{1}{4}$ in. thick "Perspex" sheet placed in position (shrink fit) and cemented with chloroform. The spray container was thus divided into two compartments, the upper with a total volume of about 1,200 ml and the lower about 330 ml when the teats are in position.

Fig. 1—Concentrate chamber. Plan of mixing pattern of rubber teats, and cutaway view of lower part of cylinder showing: A. "Perspex" partition. B. "Perspex" spigots to take rubber teats. C. Rubber teat in position showing slits. D. Metal tube conveying air pressure to upper chamber. E. Rubber liquid-tight seal for D. F. "Perspex" side tube for filling. G. "Perspex" cap for F. H. Rubber seal.

Two small "Perspex" side tubes were threaded and cemented into positions in the cylinder wall just below the partition so that the lower chamber could be filled independently with concentrate.

The five rubber teats, selected for uniformity of size and wall thickness, were each punctuated in a pattern consisting of two sets of four vertical slits and one extra slit at the tip (Fig. 1), excepting that, for the teat located centrally over the outlet, the slit at the tip was omitted. The slits were 3/32nd in. to 1/8 in. in length and were made by piercing the rubber wall with the tip of a long narrow scalpel blade. Exact uniformity was not attempted and tests carried out with teats of a different shape and size gave comparable efficiency. The main factor appears to be that the spray pattern of the teats should give as even a distribution as possible.

SPRAY BOOM

For versatility and accuracy it was decided to construct a new four-nozzle spray boom which would allow independent adjustment of each nozzle for spacing and alignment and provide separate tubes of equal length to convey the liquid to each nozzle.

"Dural" rod, 1/8 in. diameter, formed the T-shaped framework and the T-junction was provided with a swivel joint clamped by a 5/16th in. Whitworth wing-nut. This latter arrangement is advisable where an operator is required to spray a plot without walking on the sprayed area.

Nozzle blocks were assembled from standard automobile parts. For each nozzle were required:

- 1 "Rotherham" nut, Whitworth thread.
- 1 male connector, Whitworth/S.A.E. threads.
- 1 flared female union, S.A.E. thread.
- 1 flared nut, S.A.E. thread.

A small block provided with a 1/8 in. hole and grub screw was brazed to the male connector to provide a simple means of attachment to and adjustment on the boom. The standard ceramic-fan jets used were accessories supplied with the original sprayer.

A small cylindrical four-way distributor was made from hard brass, and the four tubes to convey the mixture to individual nozzles were of 3/16th in. internal diameter clear flexible plastic tubing, wired on at the distributor ends, and fastened with the flared unions at the nozzles.

OPERATION

With the equipment assembled and in position with all valves closed the caps are unscrewed from the side tubes of the concentrate chamber. A funnel and short length of rubber tubing enable easy and rapid filling. When all air bubbles have been expelled by the incoming liquid the caps are replaced.

The upper or diluent chamber is then unstoppered, filled with the aid of a funnel, and resealed.

The sprayer is now pressurised as far as the handpiece by opening the pressure cylinder valve and the spray chamber liquid outlet valve. Provided that the spraying pressure has already been regulated for the jet sizes fitted, the sprayer is ready for use.

The spraying operation is then commenced by opening the valve in the handpiece, and the resultant transference of liquid from the diluent chamber to the concentrate chamber is by way of the perforated teats. At the pressures (25 to 30 lb per square inch) and the jet size used (four size 0 jets) violent agitation occurred in the concentrate chamber and the calibration results indicate a high degree of mixing efficiency.

If the outlet valve is open while the concentrate tank is being filled, the short length of pressure hose leading to the hand piece may become partly or entirely filled with concentrate. This can cause a variable time delay of up to one half-second in commencement of the desired logarithmic dilution rate. Though both filling methods have given satisfactory logarithmic dilution rates, one method only should be used for exact repro-

ducibility, and it is most important, of course, that the procedure which is used when conducting calibration tests is strictly adhered to in actual operation.

Fig. 2—Result of an actual calibration test with logarithmic modification.

CALIBRATION TESTS

For testing the performance of the modified sprayer two aqueous solutions were used, one containing 250 p.p.m. potassium as potassium chloride and the other 250 p.p.m. calcium as calcium chloride, in the respective chambers.

Size 0 ceramic fan jets delivering at 30 lb per square inch pressure were fitted for the tests, and samples (approximately 11.0 ml) were collected at 1 second intervals.

ESTIMATION OF SAMPLES

The relative amounts of potassium and calcium in each sample were estimated by flame photometry. The fact that two solutions were used and estimated simultaneously provided a valuable check on the accuracy of the estimations, and also the possibility of contamination or unexpected dilution due to residual distilled water in the apparatus.

Out of more than 200 estimations only one appeared to be anomalous, and it was impossible to repeat this particular estimation as insufficient sample remained. The calibration tests proved to be highly reproducible over the range from 80 per cent concentration to 8 per cent, and a representative example is shown in Fig. 2. For a wider spread of the logarithmic concentration range the capacity of the concentrate chamber must be reduced accordingly. Approximately 2.0 seconds were needed for the required logarithmic dilution rate to be achieved, and once the diluent chamber was emptied the dilution rate again became unstable. The estimation of the relative amounts of potassium and calcium present in the calibration samples indicates that the delay in achieving the correct dilution rate is due to distilled water in the tubing or valves after rinsing and blowing out. Further tests have been carried out to ascertain the causes of the irregularities at the commencement of the scale, as an adjustment in the strength of the concentrate solution, together with the requisite time or distance allowance before the commencement of an actual plot, was not considered the best way to overcome the deficiency at the upper end of the concentration scale.

Additional tests have shown that for greatest efficiency of dilution the mixing chamber should be located as close as possible to the spray boom, and the bores of the separate tubes conveying the mixture to each nozzle should be as small as possible ($\frac{1}{8}$ in. diameter is recommended). By doing this, it was found that the time delay between opening of the valve and the emergence of liquid from the jets was negligible, the danger of dilution by rinse water remaining in the tubes was almost completely removed, and the sprayer gave a logarithmic dilution from the commencement of the run until the diluent chamber was exhausted.

ALTERNATIVE CALIBRATION METHODS

Other calibration methods have been employed, for example, dye solution collected on filter paper strips and estimated by colorimetric methods (Hartley, Pfeiffer, and Brunskill 1956), also another involving refractive index measurements of calcium chloride solution (Leasure and Falkenstein 1958).

Though the flame photometry method employing two solutions, as already described, proved efficient, fast, and highly reproducible, the dye method has an additional value in that it reveals the transverse distribution characteristics of the jets. Before employing a precision sprayer on field work, it is advisable to use a dye test to ensure that jet distribution characteristics, spacing, and delivery height from the target are arranged to give the best possible utilisation of the accuracy of the remainder of the equipment. Methyl violet marking ink, 1 part to 20 parts of water for the concentrate, and water as the diluent can be used for this purpose.

DISCUSSION

Possible uses for the logarithmic spraying technique have been mentioned previously by Hartley et al (1956) and Leasure and Falkenstein (1958) and additional uses will probably be realised.

Some of the most valuable applications of the general techniques are expected to be as follows:

1. Determination of the most effective application rates for herbicides or related chemicals.
2. Comparison of two chemicals in relationship with each other, either by varying the concentrations of each or by varying the concentration of one while keeping the other fixed.

3. Determination of correct rates of application of individual minor elements or combinations of some to pastures.

The main features of the modification described and the mixing principle employed are:

1. Simple workshop facilities are sufficient for the modification of existing equipment.
2. The cost of necessary materials and fittings is low.
3. The modification of the spray chamber for logarithmic spraying does not preclude its use in the original role, as removal of the rubber teats is all that is required for the reversion.
4. There are no mechanical or moving parts requiring maintenance, hence no cost of upkeep apart from the occasional renewal of teats.

A number of officers of the Department of Agriculture have collaborated in the planning of a basic portable spraying unit incorporating the most desirable features for simple and efficient operation and versatility, in which the conversion from fixed rate to logarithmic spraying can be quickly effected by having logarithmic mixing chambers of required capacity and dilution rate as accessory equipment.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of fellow officers of the Rukuhia Soil Research Station, particularly F. B. Thompson, for the original suggestion indicating the potential value of the modification of existing equipment, and providing assistance in the calibration and other testing work; and also J. E. Allan and staff of the spectrographic section for the determination of potassium and calcium in the calibration samples.

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