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DYE TESTS ON A CHESTERFORD LOGARITHMIC DOSAGE SPRAYER

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SUMMARY

Tests on a Chesterford Mark IV logarithmic dosage sprayer, comparing different proportions of the same chemical in the concentrate and diluent vessels, showed that dosage at 5 yd along the plot was independent of the concentration of chemical in the diluent solution. After that point, dosage was determined by the concentrate and diluent solution strengths.

Observed dosages ranged between 75 and 116% of the theoretical, with 93% within ± 10% of the theoretical value. The percentage by which observed dosage differed from the theoretical value was not markedly affected by the concentration of chemical in the diluent or the distance along the plot.

I. INTRODUCTION

The technique of logarithmic dosage spraying has been known for some years (Pfeiffer, Brunskill and Hartley 1955). Sprayers which operate on this principle enable the investigator to apply varying dosages of a herbicide to a single plot, from which a range of crop and weed responses may be observed.

Variable dosage is achieved by drawing chemical at a constant rate out of a small concentrate vessel to the nozzle system, and replacing it at the same rate with a diluent such as water. Provided the diluent and the concentrate chemical are rapidly and completely mixed, and the sprayer moves at constant speed, the chemical dosage decreases exponentially along the plot.

Kaupke (1966) considered the theory in the design and operation of logarithmic sprayers and outlined modifications to provide flexibility under a variety of application conditions. He showed that the effective half dosage distance of the sprayer could be increased by using different proportions of the same chemical in the diluent and concentrate vessels (Figure 1). Earlier, Brunskill (1957) described this modification but did not investigate it in detail.

In 1962 dye tests were carried out on a Chesterford logarithmic sprayer to study the use of different proportions of the same chemical in the diluent and concentrate vessels; these results are presented and compared with the theoretical values calculated from Kaupke's paper.

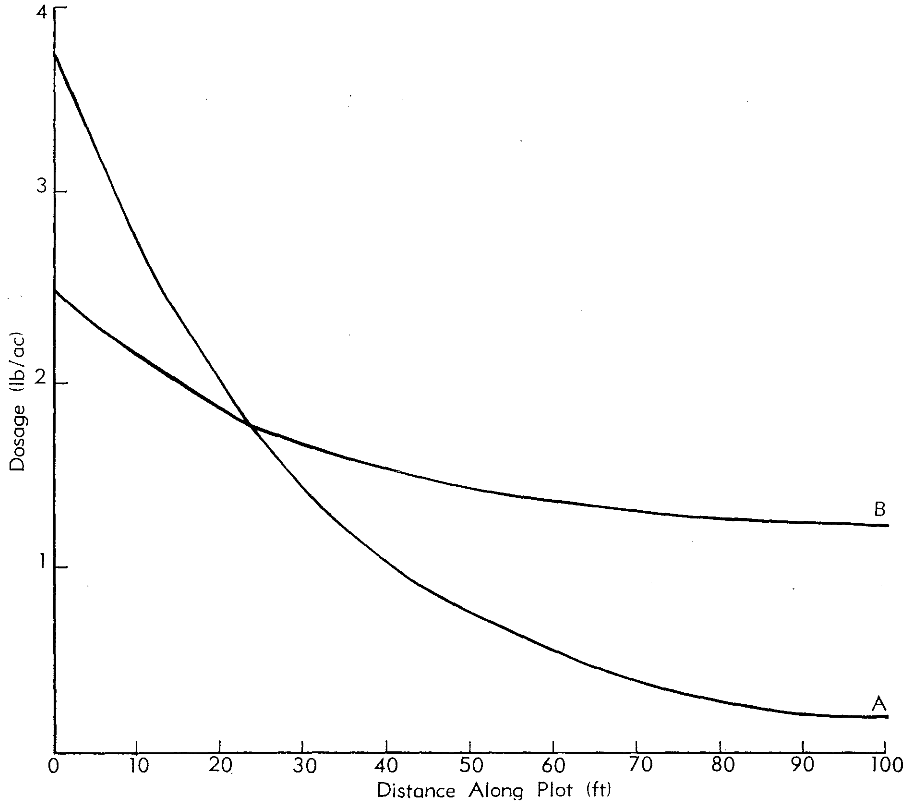

Fig. 1.—Theoretical curves for treatments A and B. A shows the effect of no chemical in the diluent solution and B the effect of different proportions of the same chemical in the diluent and concentrate solutions.

II. MATERIALS AND METHODS

A Chesterford Mark IV logarithmic spraying machine driven from the power-take-off of an 88 in. wheel-base Land Rover was tested. Ceramic nozzles with a flat fan pattern and an 80° spray angle were spaced at 9 in. centres along a 14 ft boom. With this particular sprayer the first 5 yd of the plot are ignored because a short time is needed for both the vehicle and the sprayer gear pump to accelerate to operating speed. Also, at the same time, air has to be expelled from the small distributor below the gear pump and from the tubing joining each nozzle to the distributor. After 5 yd a strictly logarithmic decrease is achieved (Anon.)

Water-soluble Kiton Fast Red G dye was employed as the test chemical. Spray was collected on Whatman No. 5 filter papers of 15 cm diam. Preliminary tests had shown that this paper was suitable for the purpose.

Tests were done out of doors during fine weather on compacted clay loam. Slight spray drift was observed during 2 of the 20 spray runs, but it is doubtful if this influenced the overall test results.

Spraying was carried out at 3·6 m.p.h. with the vehicle engine governed to give 500 r.p.m. at the power-take-off. Under these conditions the application rate was 33 gal/ac, and the half dosage distance of the sprayer, estimated from dye calibration, was 21·7 ft.

Dye solutions were made up with rain water. The five treatments tested are shown in Table 1. Each treatment was repeated four times and sampled every 10 ft over a length of 100 ft. Altogether there were 11 sampling stations positioned at right-angles to the spray run. Stations were 13 ft wide with two 1·5 ft gaps in the centre to allow free passage of the vehicle wheels. The 13 ft width, excluding the wheel track gaps, was divided into 20 sections each of 6 in. width and six filter papers were assigned at random to these for each spray run. Filter papers were centred below a string stretched between two outside datum pegs and pinned to thin pine boards laid on the ground. The guide strings were removed before each spray run.

To ensure even spray distribution the height of the nozzle tips was adjusted to give uniform triple spray coverage at ground level. This was achieved by varying the load on the rear springs of the Land Rover by adjusting the water level in a spare tank.

At the start of each run the vehicle was positioned so that the ends of the boom were in line with two pegs sited 5 yd from the first sampling station. The valve connecting the diluent and concentrate tanks was then opened. When this valve is opened a small amount of nozzle drip occurs, and to make this as constant as possible, exactly 2 min were allowed between opening and setting the vehicle in motion with the power-take-off engaged.

After spraying, the papers were allowed to dry *in situ* and trimmed of portions where the drawing-pin heads had interfered with spray coverage. The area of each trimmed paper was then calculated. The six papers from each station were bulked and the amount of dye on these estimated colorimetrically after eluting with water.

TABLE 1

SPRAY CONCENTRATION AT THE FIRST SAMPLING STATION 5 YD ALONG THE PLOT, EXPRESSED AS A PERCENTAGE OF THE ORIGINAL CONCENTRATE SOLUTION

Treatment dye μ g/c.c.			Concentration at 5 yd as a Percentage of the original Concentrate	
Concentrate Solution		Diluent Solution	Mean*	Trans. Mean†
A.	13,050	0 (water only)	87·3	(70·6)
B.	8,690	3,150	85·0	(67·1)
C.	7,450	4,510	86·8	(69·3)
D.	6,950	4,900	87·3	(69·7)
E.	6,730	5,090	83·9	(66·4)
		Mean	86·1	(68·6)
		S.E. of mean		(2·96)
		L.S.D. (5%, 1%)		n.s.

* Raw mean † Arc sine$\sqrt{\%}$ transformation.

III. RESULTS

To determine if the dosage at the first sampling station was influenced by the concentration of chemical in the diluent, observed dosages at this point were expressed as a percentage of the original concentrate and the data then subjected to analysis of variance (Table 1).

Table 1 shows that the dosage at 5 yd along the plot was independent of the concentration of chemical in the diluent solution. The dosage at this point averaged 86·1% of the original concentrate. This figure was used to calculate the theoretical dosages at the first sampling station. Comparisons between observed and theoretical dosages for the remaining stations were made by expressing the observed concentration as a percentage of the theoretical (Appendix 1). Theoretical values were obtained from one of the equations given by Kaupke (1966) which had been slightly modified (Appendix 2). Kaupke worked in terms of concentration in the concentrate chamber, whereas with this particular sprayer it is necessary to consider concentrate strength in terms of dosage at 5 yd along the plot (Anon.). Table 2 shows that observed values differed from the theoretical by approximately the same percentage for all treatments. Of the observed values, 93% fell within ± 10% of the theoretical figure.

TABLE 2

NUMBER OF SAMPLES FALLING WITHIN EACH CATEGORY

TREATMENT	Dosage as a Percentage of the Theoretical										
	< 82	> 82 to 86	> 86 to 90	> 90 to 94	> 94 to 98	> 98 to 102	> 102 to 106	> 106 to 110	> 110 to 114	> 114 to 118	> 118
A	0	0	2	10	7	13	5	5	0	2	0
B	0	0	0	3	4	12	14	8	3	0	0
C	0	0	0	3	9	11	10	7	4	0	0
D	1	0	0	5	12	12	4	10	0	0	0
E	0	0	1	5	13	16	6	0	3	0	0

Observed dosage at each sampling station differed from the theoretical value by approximately the same percentage, regardless of the distance along the plot. Slightly higher percentages were recorded at the second and third stations; this may have been due to slight malfunctioning of the vehicle governor. Observed percentages at each sampling station, averaged over all treatments, are presented in Table 3.

TABLE 3

Observed Dosages at Each Sampling Station Expressed as a Percentage of the Theoretical Value (Averaged over all Treatments)

Sampling Station		Mean ± S.D.	Range
1	(0 ft)	100 ± 6	93–115
2	(10 ft)	105 ± 5	97–114
3	(20 ft)	107 ± 5	95–116
4	(30 ft)	100 ± 7	75–109
5	(40 ft)	97 ± 3	94–106
6	(50 ft)	100 ± 5	92–108
7	(60 ft)	100 ± 4	95–111
8	(70 ft)	99 ± 6	90–110
9	(80 ft)	99 ± 5	91–107
10	(90 ft)	98 ± 5	87–106
11	(100 ft)	98 ± 6	86–108
Overall mean		101 ± 6	75–116

IV. DISCUSSION

The fact that the dosage at 5 yd along the plot was independent of the diluent suggests that over the first few yards no appreciable amount of diluent enters the concentrate chamber of this particular sprayer. Hence the reduction in strength of the original concentrate must have been due largely to the application rate at 5 yd being lower than the operating output. This can be understood when it is realized that initially the pump must accelerate and force air from the distributor and delivery tubing. The mean application rate at 5 yd was 28·49 gal/ac, compared with the theoretical value of 28·55 gal/ac calculated from the service manual for the sprayer (Appendix 1).

These tests show that under favourable operating conditions, for this class of sprayer, dosages may be expected to vary from the theoretical value by ± 10%.

V. ACKNOWLEDGEMENTS

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Appendix 1

Terms used in the text are defined as follows:

Dosage = g of dye per sq cm at any particular position in the plot.

Concentration = g of dye per c.c. of solution.

Application rate = gal of spray applied per ac when the vehicle and sprayer pump have accelerated to working speed.

Half dosage distance = distance travelled by the time the initial dosage (i.e. dosage at 5 yd for the Chesterford Mark IV logarithmic) has been halved. For this particular sprayer the dosage (D) at 5 yd, expressed in gal of original concentrate per ac, is given by:

$$\log_{10} D = 3{\cdot}756 - \log_{10} vt - \frac{25{\cdot}22}{vt} \text{ (Anon.)},$$

where v = land speed of vehicle in m.p.h.
and t = no. of seconds to spray out 2 Imp. gal.

Note: Where necessary, dosages (g/sq cm) were converted to concentration (g/c.c.) by dividing the dosage by the application rate expressed in c.c./sq cm, 1 Imp. gal/ac being taken as $1{,}123 \times 10^{-7}$c.c./sq cm.

Appendix 2

Theoretical dosages for stations 2 to 11 inclusive were calculated from Kaupke (1966), equation 4, which had been slightly modified. The equation used was:

$$\frac{x}{x_o} = \frac{y_o}{x_o} + (\tfrac{1}{2})^{L/L_h} (1 - \frac{y_o}{x_o}),$$

where

x = theoretical concentration of dye at L ft along the plot in g/c.c.
x_o = concentration of dye at 5 yd (first sampling station) in g/c.c.
y_o = concentration of dye in diluent tank in g/c.c.
L = distance travelled along the plot in ft.
L_h = half dosage distance in ft.

Note: For these calculations x_o was taken to be 86·1% of the original concentrate strength.

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