APPLICATION TECHNIQUES

Chairman: Mr. M. N. Gladstone

Research Report No. D.1

THE CHESTERFORD LOGARITHMIC SPRAYER

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Part 1 - General

Introduction

The established method of assessment of agricultural chemicals in the field necessitates spraying a large number of small plots in separate operations, using different dilutions of chemical. Washing out the machine and making up dilutions consumes the major portion of experimental time. The Chesterford Logarithmic Sprayer has been designed to meet the requirement for a machine which carries out dilution continuously as the spraying proceeds, so that a whole spectrum of concentrations can be applied in one operation.

Equivalent increases of biological response are generally produced by equivalent relative increases of concentration, and consequently it is desirable that the spectrum of dosage should be on a logarithmic scale so that the dosage is halved for every additional standard distance of travel of the machine. It is fortunate that the simplest method of securing automatic dilution gives this particular relationship.

Dilution principle (for further discussion see Part 2)

The principle of dilution used in this new machine is to pump liquid to the spray nozzles from an intermediate vessel which is otherwise closed, except for a tube leading from a supply of diluting liquid, usually water. This intermediate vessel is equipped with an efficient agitator and is initially completely filled with the chemical at a concentration rather higher than the maximum expected to be of interest. As spray liquid is drawn from the intermediate vessel it is replaced by an equal quantity of the diluting liquid, and the concentration therefore falls in an exponential manner.

When spraying proceeds in a standard manner from a vehicle moving at constant speed, the volume sprayed out is proportional both to time and to distance. The proportionality to distance is of primary importance with regard to this type of experiment, since the concentration is then an exponential function of distance along the plot, or, otherwise expressed, the distance is a logarithmic measure of the concentration. A gear pump is therefore used in a range where its output is approximately proportional to speed.

Advantages of the new spraying technique

The most important advantage of the new technique is economy of time and labour. After a whole season's experience of this machine in field work, it is found that only one-third to one-fifth of the time necessary on the old methods is required to lay down, by the new method, plots giving at least as much information.

When testing herbicides there are other very clear advantages resulting from the ability to observe the effect of continuously decreasing dosage. If a plot contains both crop and weeds and is selected to be reasonably uniform, one sees after a few weeks in most cases a fairly sharply defined region, on the dilute side of which the crop has been unharmed by the spray. If the weed-killer is highly selective, one will have to go still further towards the lower concentrations before reaching the fairly well-defined region, on the high concentration side of which the weeds are dead or moribund. One can thus easily measure, directly in terms of distance and by reference to the calibration graph in terms of dosage ratio, the margin of selectivity in which the experimenter is primarily interested, that is to say the ratio of the maximum concentration which the crop can stand without apparent damage to the minimum concentration necessary to control the weeds. Traditional methods, on the other hand, can only be used to measure easily the ratio of concentrations producing the same effect (e.g. 50% kill) on weed and crop, and even this measurement is achieved with more labour and by the use of interpolation methods which may have to assume a normal dosage-response curve.

The use of this new method may require some modification of accepted statistical analysis, and it must be emphasised that the method in no way reduces the necessity of replication. While the desired margin of selectivity referred to above can be measured fairly precisely in any one plot in any one set of conditions, it does not by any means necessarily follow that it will be the same if the spraying is repeated later in the year or on a different soil or under different weather conditions. Rather than replacing the necessity for replication in field work, the machine should be regarded as enabling much more replication to be done, because of the great economy of time and labour which its use permits.

Choice of conditions

It will be noted that the rate at which the concentration falls off along the plot is determined by the volume of the intermediate vessel into which the concentrate is filled (this will subsequently be referred to as the concentrate vessel) and by the volume of spray delivered per unit distance of travel of the machine. It has not so far been found practicable to work with a concentrate vessel of variable volume, and it is not normally practicable to vary the rate of output very greatly without substitution of the pump. A compromise has, therefore, had to be made on the most generally useful values for spray rate and concentration decrement. For convenience the latter is measured in terms of the distance of travel of the machine necessary to halve the concentration and this is termed the half dosage distance.

The practical points taken into consideration in arriving at this compromise figure are:-

1. The machine is pre-eminently suitable for assessment of herbicides. Its use for the assessment of insecticides and fungicides has been considered as secondary.

2. Spray rates generally used in herbicide application vary from about 5 gal to about 100 gal/ac.

3. Under normal conditions exact uniformity of spray dosage over small areas is very difficult to achieve. Not only is it necessary to have the nozzle separation accurately adjusted so that the dosage is uniform across

the plot, but there are also variations induced by gustiness of wind, which may blow the spray slightly forward during the one fraction of a second, and cease to do so during the next, and by swaying of the boom if uneven ground is traversed.

These considerations have led to the choice of a standard dosage rate of 30 gal/ac and a standard half dosage distance of 6 yd. Certain variations on these standards can be attained by small modifications in the assembly of the machine and its use, but larger variations may require the fitment of an alternative concentrate tank and/or an alternative pump. These matters are discussed in Part 3.

Practical considerations in the method of operation (for further details see Part 3)

The method of spraying which the basic principle of this machine makes practicable requires another important departure from the orthodox spraying machine. Since the simplest possible lay-out of a continuous spectrum of concentrations is required, it is necessary that the concentration should not vary across the plot but only along it. This means that the same time must be taken for liquid to travel to all the nozzles from the tank where its concentration is diluted. The nozzles cannot therefore be fed from a common boom, as in a normal commercial machine. Instead they are fed through thin flexible tubes (of polythene) originating from a common manifold distributor very close to the pump. The length of the tube is of course determined by the length necessary to reach the most remote nozzles, the spare length of the leads to the near nozzles being accommodated in a suitable coil.

The mathematically ideal method of using this machine would be to start with the nozzle leads and nozzles completely empty, so that, on switching on the pump, one would attain almost instantaneously the initial concentration followed by a strictly exponential decrease. However, a pump does not attain its full speed instantaneously, nor is it practicable when carrying out successive sprayings completely to empty the leads and nozzles. Experience has shown that only a very short time is required from start-up of the pump to spraying maximum concentration, and for this reason, approximately the first 5 yd only should be ignored in any experiment. In each machine the concentration sprayed at 5 yd will be the dosage in terms of gal/ac of concentrate at this point. The graph of concentration against distance, of which practical examples are shown in this report, is therefore characterised by a short period after the operation of the pump during which air is expelled from the polythene leads, followed by a very rapid ascent to a peak concentration somewhat less than that initially present in the concentrate tank, settling down very rapidly to a steady exponential fall of concentration with further distance.

The dosage applied at any distance from the point where the pump started operating can be quickly calculated from the calibration graph for the machine and the value of the concentration initially charged into the concentrate tank. A convenient nomogram for this calculation has been constructed.

It will be appreciated that this sprayer can also be used as a conventional spraying machine. Having found the optimum concentration of the chemical used on the logarithmic plot, this concentration can be made up and sprayed in place of the water (no concentrate being put in the concentrate tank).

Similarly it is, of course, sometimes convenient to apply two chemicals simultaneously, one at a fixed concentration instead of diluent water, the other at a concentration which falls off exponentially. Thus the one machine is able to fulfill three distinct functions.

Mounting of the machine (See Part 4, mechanical specification. Complete mounting and working instructions will be sent with the machine).

The standard machine is designed for fitting to the back of the 4 - wheel Land Rover, preferably the short wheel base model, which is more manoeuverable under field conditions. The pump and agitator are driven from the power-take-off at the rear of the machine. The Land Rover (or its American equivalent, the Jeep) is a very suitable machine for this type of work, as it combines the function of transport to the site with spraying on the site. The four wheel drive system reduces the wheel slip to a minimum and consequently does not upset the distance/concentration calitraticn. The framework of the machine is bolted to the chassis of the vehicle. In view of the specialised nature of this machine it is not possible to supply various fittings but it is possible for the unit to be modified to suit other vehicles with power-take-off shafts.

Note A user is advised in his own interests to consult local traffic authorities about necessity for extra number plate, rear light, etc.

Checking the performance of the machine (For details see Part 3)

No machine is infallible, and it is strongly urged that some form of recalibration of the machine from time to time is desirable during a season's use.

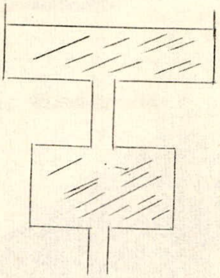
Apart from the development of definite mechanical defects due to accident, corrosion or misuse, which can easily be detected and repaired, there is likely to be some slow change in the pump, leading respectively to a higher or lower output of liquid than was originally designed. The effect of this can be quite accurately allowed for if it is known, and in the more detailed description that follows a method is recommended for periodically checking the actual output/yd run of the machine, so that the necessary small correction to the calibration graph can be made from time to time.

The machine is also subject to some of the troubles inherent in the use of spraying machines generally. Blockage of nozzles can of course upset an experiment, whether it is done with a constant dose sprayer or the new machine, and therefore all reasonable care should be taken to avoid the use of dirty water or formulations which precipitate tarry matter; and care taken to leave the machine when idle in a completely clean condition. The usual precaution has been taken of providing a filter, both between the water tank and concentrate vessel and between the pump and nozzles. The machine has one positive advantage in the matter of the discipline of cleanliness in that when used with water as a diluent, the parts of the machine designed to cope with chemicals, namely the concentrate tank, pump, leads and nozzles are automatically self-washing. A short period of blank spraying is recommended at the end of every plot before charging in the next chemical, and a short period of blank spraying at the end of a day's work ensures that the machine is put away with the vital parts containing water only.

Part 2 - Theoretical Considerations

1. Fig. 1 illustrates the two-tank arrangement in the logarithmic sprayer. Tank A contains the diluent, normally water, and Tank B contains the concentrate solution.

Fig. 1



Tank B is assumed to be intimately mixed at all times.

Let the concentration of active ingredient in Tank B at time t be C. Let the total volume of tank B be V. If a small volume of liquid $v\delta t$ is extracted from B and replaced by an equal volume of diluent from A, the new concentration in B, (B + δC) will be given by:-

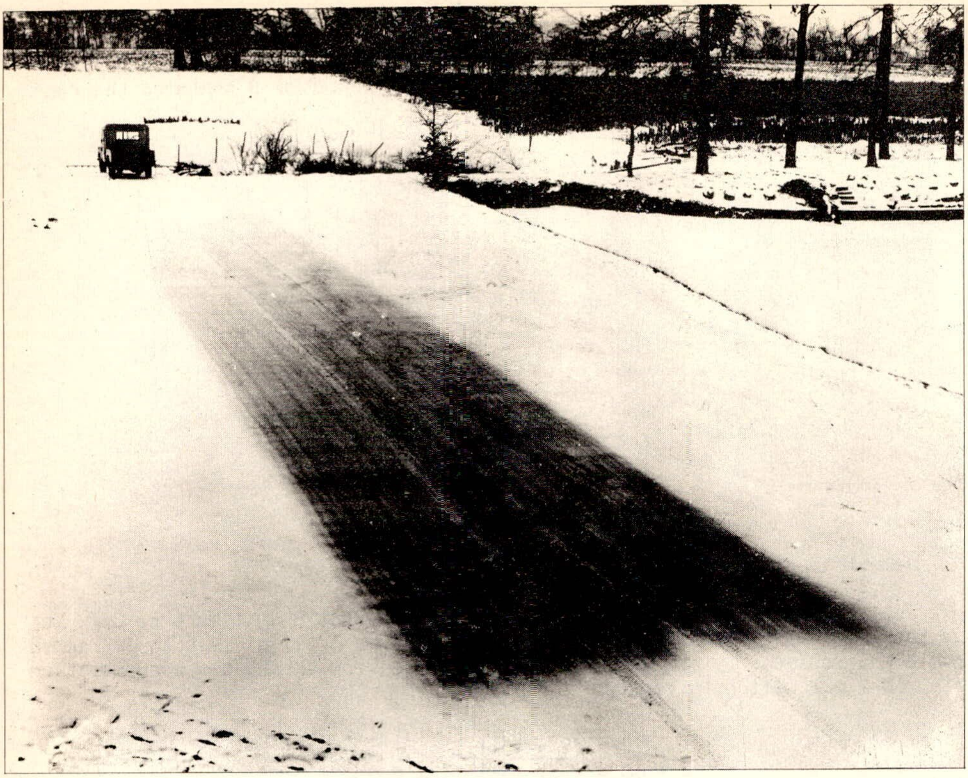
$$C + \delta C = \left(\frac{(V - v\delta t).C}{V}\right) = C - C\frac{v\delta t}{V}$$

$$\text{i.e. } \delta C = -C\frac{v\delta t}{V} \quad \text{or} \quad \frac{\delta C}{\delta t} = \frac{-Cv}{V}$$

i.e. $\underline{C = C_0 e^{\frac{-vt}{V}}}$ (Equation 1) where C_0 is the value of C at time t = 0 and v is the flow rate of the liquid.

The concentration of active ingredient in Tank B will therefore follow a purely exponential law with time.

2. Confirmation of the ultimately strictly logarithmic decrease of concentration with time, as predicted from the above analysis has been obtained by sampling the liquid ejected by a gear pump positioned immediately after the concentrate tank B. The experimental unit was mounted on a Land Rover, the pump being driven from the power-take-off shaft. The Land Rover was driven at a governed speed of 3 m.p.h. and the output from the pump was sampled at 1 yd intervals. The variation of concentration with distance can be seen in Fig. 2.



A dye sprayed onto snow showing
logarithmic decrease in dosage.
Halving of dosage occurs every 6 yards

The logarithmic decrease in concentration is very evident. It should be mentioned in passing that the concentrate tank used for this experiment was much smaller than those eventually fitted to the field units. In addition the distance scale is purely arbitrary.

Part 3 - Practical Considerations

1. Calibration

The logarithmic sprayer can be calibrated by filling the concentrate tank with a red dye solution and spraying an experimental plot in the standard manner. Strips of filter paper carried in aluminium containers are laid on the ground at right angles to the direction of travel at 1 yd intervals. Three series of such strips 3 ft long and 2.5 in. wide are laid down so as to sample the spray from the right, centre and left hand booms as spraying proceeds. The Land Rover is driven forward at a governed rate of 3 m.p.h., starting with the pump 5 yd before the first row of filter papers, the nozzle separation on the boom being fixed at 9 in. At the conclusion of spraying, the paper strips are allowed to dry. One sample 36 in. x 2 in. is taken from each filter paper strip and eluted in a fixed volume of water. The colour density of each solution is then estimated using a standard colorimeter. It is important in a calibration of this nature to use a dye which elutes readily from filter paper, which is light - stable and, to some extent, not pH sensitive. In addition, the filter paper used should not disintegrate on elution. This eliminates the laborious task of filtering the individual solutions. Kiron Red G 200%, (British Colour Index No. 31) has been found a suitable dye, and Whatman No. 50, a suitable paper.

2. Fig. 3 is a mean calibration graph for the overall boom. The dosage is presented along the logarithmic scale of the ordinate as equivalent gal/ac of the the original solution in the concentrate tank. The distance travelled in yd is presented along the abscissae with the position of the boom on the stationary Land Rover prior to commencement of spraying located at the origin. This position will be referred to throughout this memorandum as the starting point.

It will be seen by reference to Fig. 3 that at 5 yd after the starting point, the decrease in dosage with distance is strictly logarithmic, and this point, 5 yd after the starting point, will be referred to as the beginning of the plot.

3. Calibration nomogram for field use

The results of the calibration of any unit are presented in a more general and comprehensive form as a nomogram. The nomogram, which has been prepared for field use, is presented in Fig. 4. The three linear axes represent respectively the distance of travel along the experimental plot (x), the half dosage distance for the sprayer (y) and dosage of the active ingredient as a fraction of the peak dosage ($D/_{D_o}$).

For any one logarithmic sprayer a specific half dosage distance is quoted, also a distance figure in yd between the starting point and the beginning of the plot, and the equivalent dosage sprayed at this point (D_o). The machine sprays, of course, at a constant volume/ac, solution of diminishing concentration. Mathematically this is equivalent to spraying initial concentrate at a decreasing volume/ac, the constant total volume/ac being made up with increasing volume of diluent. For calibration purposes this second method of expression is much more convenient. Dosage is therefore expressed in what follows as gal/ac of initial concentrate. Referring to the mean calibration graph of Fig. 3 for example, the half dosage distance is 6.15 yd, the distance between the starting point and the beginning of the plot is 5 yd (Point A) and the dosage at this point is 25 gal/ac of concentrate. It is important to realise that the point chosen for the beginning of the experimental plot (A) is to some extent arbitrary. It is however advisable from the point of view of economy of space and chemical, to choose point A as near to the starting point as possible, provided that, at this point, the decrease in dosage with distance is strictly logarithmic.

It should be noted that distances on the nomogram are measured from the beginning of the experimental plot (Point A) and not from the starting point.

To estimate the dosage at any point in the experimental plot using the nomogram, the distance along the line of travel between this point and the beginning of the plot, is firstly measured. A straight line is now drawn on the nomogram intersecting the half dosage scale (y) and the distance scale (x) at the appropriate points. The intersection of this line with the dosage scale gives the value of $D/_{Do}$ for the chosen point.

For example, the value of $D/_{Do}$ for the present model at a distance of 10 yd (half dosage distance 6.15 yd) is about 0.33. The dosage of this point (D) is therefore 25 x 0.33 = 8.3 gal/ac of concentrate. The dosage of active ingredient sprayed will of course depend on the concentration of solution initially introduced into the concentrate tank.

4. Calculation of concentration of active ingredient

Normally the logarithmic sprayer will be used to spray an experimental plot, where the peak concentration sprayed must conform to some predetermined value.

As an example, let us assume that it is required to spray a peak dosage of X lb of active ingredient/ac. Let a concentrate solution of Y g/l introduced into the concentrate tank conform to this requirement. Let us further assume that the peak dosage sprayed by the unit is P_o gal/ac of concentrate.

Y g/l concentration = $\frac{Y}{100}$ lb/gal (Imp.)

Peak dosage sprayed is therefore $\frac{P_oY}{100}$ lb = X lb i.e. $Y = \frac{100X}{P_o}$

In the case of the present example, $P_o = 25$ and $Y = 4X$.

The standard volume of the concentrate tank is 1900 ml so that, prior to spraying, about 2 l of the concentrate solution should be prepared.

5. The standard model of the logarithmic sprayer has been designed for direct attachment to a Land Rover. Normally the sprayer will operate at a governed speed of 3 m.p.h., spraying under these conditions at a volume rate application of about 30 gal/ac. With some modification to the supporting framework it is possible to fit the unit to any vehicle carrying a power-take-off shaft. It is is important to realise however that the notes on the calibration of the unit which appear elsewhere in this report refer specifically to Land Rover fitment, and will not necessarily apply when alternative vehicles are used. Although it is possible to apply approximate corrections to the calibration nomogram to allow for fitment of the unit to alternative vehicles, it is advisable for the unit to be separately calibrated by the procedure indicated.

6. The performance and calibration of the unit are affected by three main factors which are enumerated below.

(a) The land speed of the vehicle in relation to the angular velocity (r.p.m.) of the power-take-off shaft.

(b) The volume of the concentrate tank.

(c) The separation and type of nozzles employed.

(a) The section on the calibration of the unit refers directly to the Land Rover running in first gear at minimum governed engine revolutions and with the transfer box in low gear. As stated previously, this results in a governed land speed of 3.00 m.p.h. with the power-take-off shaft revolving at 415 r.p.m. If however the transfer box is changed to high gear, the land speed of the vehicle rises to 7.50 m.p.h. but the power-take-off shaft remains unchanged. Since the volume rate output from the pump is dependent on the power-take-off shaft speed, it follows that the volume rate application will fall at the higher speed to $30 \times \frac{3}{7.5} = 12$ gal/ac, while the half dosage distance will rise by the same factor, i.e. in the present model to $\frac{7.5}{3} \times 6.15 = 15.38$ yd. Operating the unit with the Land Rover running in higher gears using either section of the transfer box is not recommended, since the resulting higher angular velocities of the power-take-off shaft will of necessity result in excessive pump output pressures.

(b) Variations in the size of the concentrate vessel will result in equivalent variations in the half dosage distance associated with the unit, providing of course that other factors are unchanged. It will be seen by reference to the mathematical section of the report that the controlling factor for the half dosage is $\frac{v}{V}$, i.e. the ratio of volume output of pump per unit travel to the volume of the concentrate vessel. For a constant v the half dosage distance is directly proportional to V. It will also be apparent that the half dosage distance is inversely proportional to v. v will be entirely dependent on the gear pump employed for fixed running conditions of the driving vehicle. If either the concentrate vessel or the pump are changed on the standard model however, it is recommended that the reconstructed unit be recalibrated rather than apply the correction factors given above.

(c) Reducing space between the nozzles along the boom, resulting in a proportional reduction in the swath width, will result also in an inverse variation in the dosage application rate. The separation of the nozzles in the model as calibrated for example is 9 in. If the nozzle separation were reduced to 6 in. the volume rate of application would rise from 30 gal/ac to $30 \times \frac{9}{6}$, i.e. 45 gal/ac. This volume rate would, under these conditions, be applied over a 9 ft swath and not as previously over a 13.5 ft swath. The half dosage distance for the unit would be unchanged.

Changing from one size of jet to another would result in indeterminate changes of the volume rate application and inverse changes in the half dosage distance.

7. Calibration of the sprayer if fitted to a vehicle other than the standard Land Rover

Where the sprayer is to be fitted to a different vehicle it is first necessary to check that the power-take-off shaft can be governed to approximately the same speed (415 r.p.m.). If widely different, suitable gearing must be introduced. It is further necessary to know the exact ratio between land speed (in the gear box position selected) and the speed of the pump input shaft. This ratio on the standard Land Rover is 3.00 m.p.h. to 415 r.p.m. If these quantities in the alternative vehicle are S and S', then all distances described in the performance of the sprayer will be multiplied by:-

$$\frac{S \times 415}{S' \times 3.00}$$

and the peak dosage divided by this quantity.

We would however recommend a complete dye concentration calibration as described above in this section.

8. Recalibration of the unit

It will be necessary at infrequent intervals to check the calibration of the unit. The calibration procedure described previously is too laborious for general adoption and the following simplified procedure is recommended:-

(a) Drain the machine completely.

(b) Measure 10 gal of water.

(c) Fill concentrate tank and close air valve of concentrate tank.

(d) Pour remainder of the 10 gal into the water tank.

(e) Commence spraying.

(f) When water appears from jets of nozzles, start stop watch.

(g) At first sign of air coming from nozzles indicating that tanks are empty, stop the stop watch.

(h) Record r.p.m. of power-take-off shaft.

This procedure enables the user to check on the consistency of the volume rate output of the pump. As an example let us assume that a new logarithmic unit has been despatched to some user with the following calibration characteristics as provided by ourselves or amended as in para. 7 by the customer:

1. Distance from starting point to beginning of plot: Z_0
2. Half dosage distance: Y_0
3. Dosage at beginning of plot: P_0 gal/ac of concentrate.
4. Time interval measured in (g) above: t_0
5. Power-take-off shaft speed: R_0 r.p.m.

The user at any later date measures the figures quoted in 4 and 5 respectively as t and R. The corrected calibration figures for use with the nomogram will now become:

1. Distance from starting point to beginning of the plot (z) =

$$Z_o \frac{t}{t_o} \cdot \frac{R}{R_o}$$

2. Half dosage distance (y) =

$$Y_o \frac{t}{t_o} \cdot \frac{R}{R_o}$$

3. Dosage at beginning of plot (P) =

$$P_o \frac{t_o}{t} \frac{R_o}{R}$$

Part 4 - Mechanical Specification

1. The logarithmic sprayer has been constructed as a self-contained unit, the essential components being rigidly attached to an angle iron framework which, in the first instance, has been adjusted for simple fitment to the rear of a Land Rover.

With some slight modification to the framework and location of the bolt holes, the unit can be carried by a Jeep. More extensive modification to the framework will be necessary if it is required to fit the unit to a tractor.

2. The pump used in the sprayer is the standard "Weedmaster" gear pump. This is driven from the power-take-off shaft of the vehicle. Mechanical agitation of the liquid in the concentrate tank is obtained using a fixed two blade vane and a rotating two blade impeller. Both vanes are perforated with numerous holes. The drive to the rotating impeller is from the pump input shaft via the chain drive with a 1 : 1 velocity ratio.

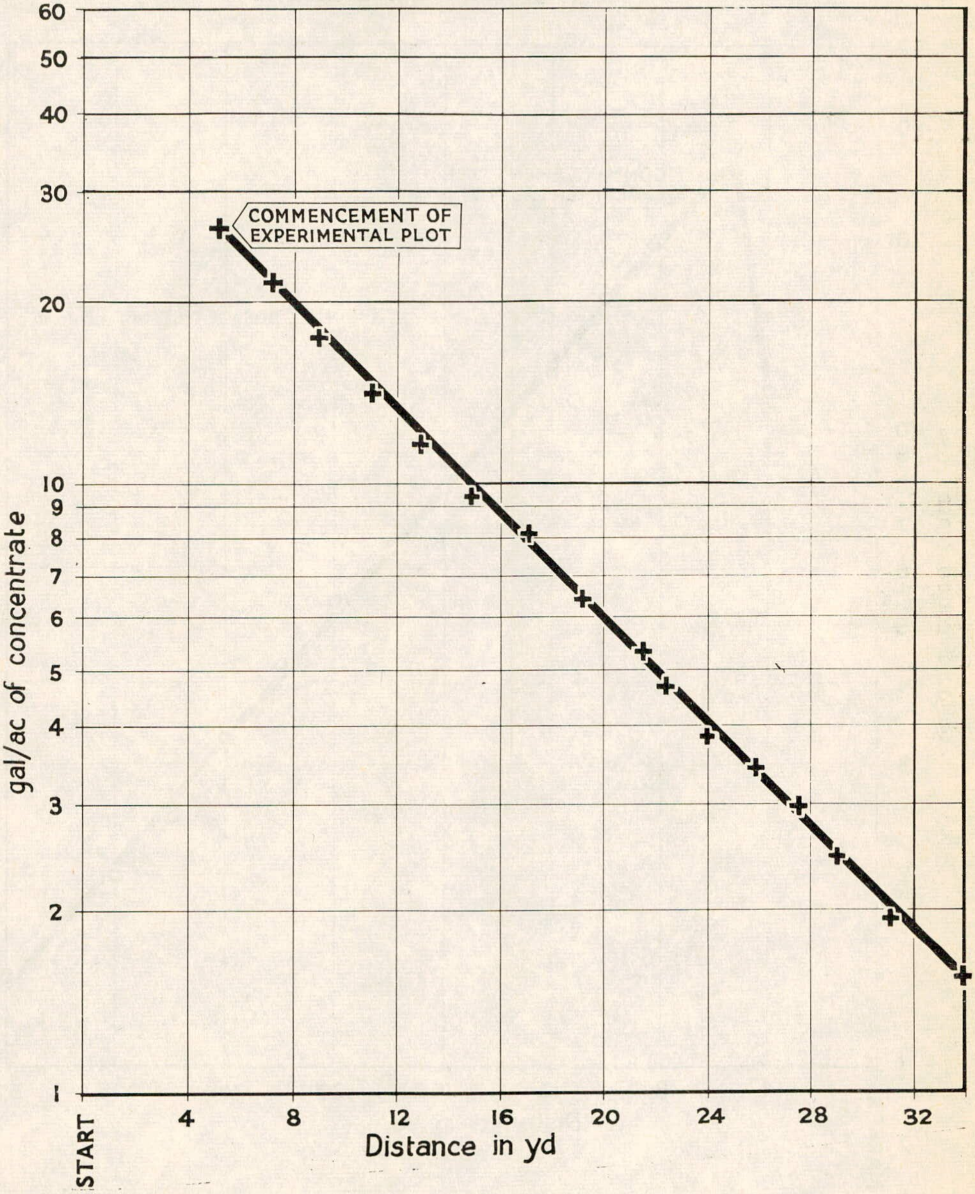
3. The outlet from the gear pump feeds directly into a 19-way distributor. The distribution of liquid is via 19 equal lengths of 0.125 in. bore white polythene tubing which connect at both the distributor and nozzles through standard brass units. The brass connector units have been designed so that the junctions with the polythene will withstand a pressure of 100 lb. White polythene tubing has been used so that the passage of the spray fluid through the translucent tubes can be observed.

The nozzle mountings on the boom are adjustable for rotation about the boom and for lateral movement along the boom. It is thus possible to direct the spray in various directions relative to the ground and to vary the dosage sprayed between about 30 and 100 gal/ac.

The individual spray jets are Bray type 733 size 00. Each set of jets has been carefully chosen for consistency of output amongst the set, so as to obtain as uniform a coverage of spray as possible over the entire boom.

4. The concentrate tank is constructed in brass, the interior being treated for corrosion resistance. The tank can be charged with liquid through a fixed funnel which connects to a 2-path valve fitted to the top of the tank. The valve is arranged to open or close the tank to atmosphere as required. A small air-vent valve is incorporated to operate with the main valve, so as to facilitate filling by preventing air locking.

Calibration Graph
Mark IV Logarithmic Sprayer



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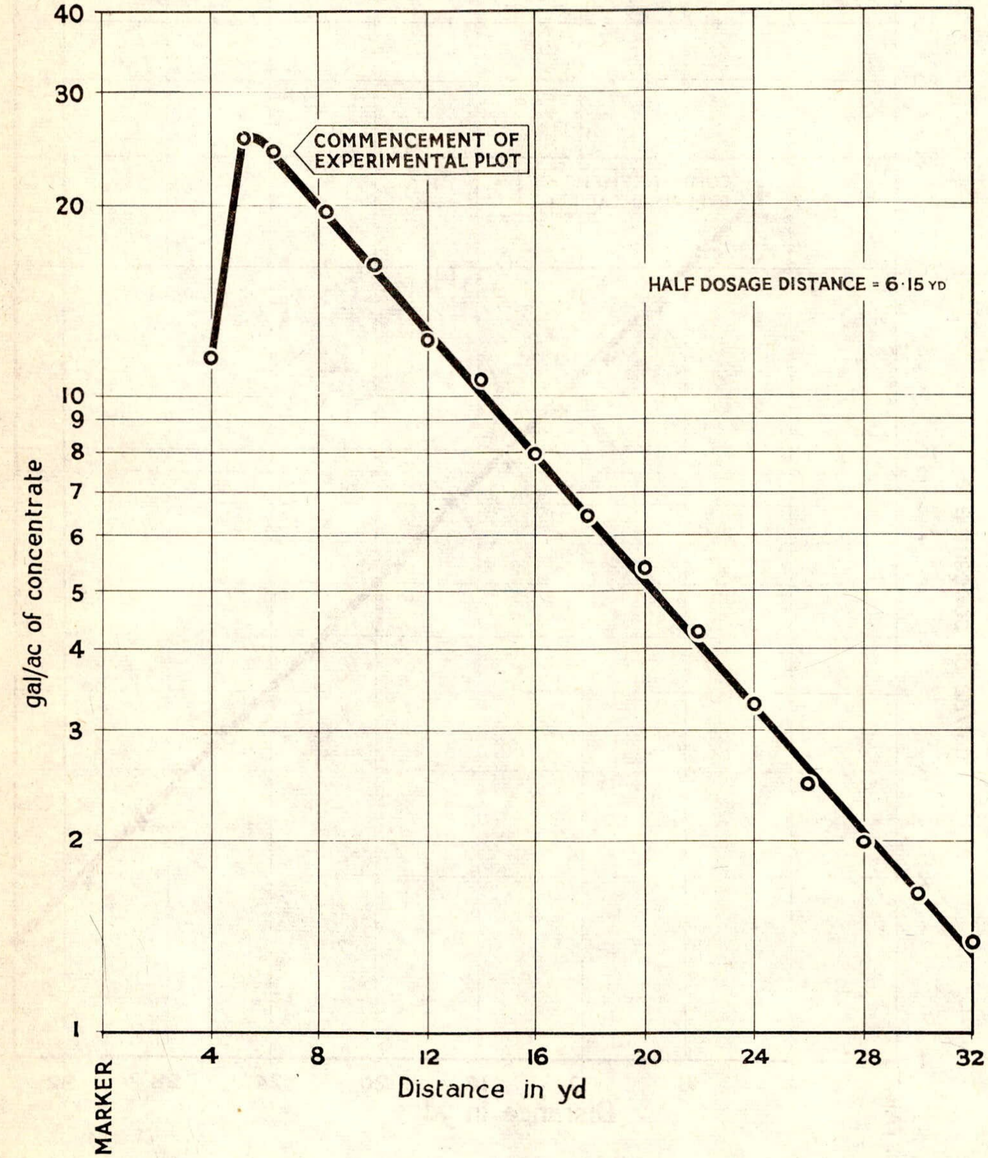
Calibration Graph
Mark III Logarithmic Sprayer



COMMENCEMENT OF EXPERIMENTAL PLOT

HALF DOSAGE DISTANCE = 6·15 YD

Research Report No. D.2

A SMALL-SCALE LOGARITHMIC SPRAYER

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Introduction

Assessment of the relative toxicity of herbicides to weeds in the field can be made by applying a series of doses of each herbicide to individual plots and measuring the degree of a selected response obtained with each dose. If 'response' is plotted against 'dose', a dose-response curve is obtained for each herbicide and a relative toxicity rating can be determined by comparing the dose of each herbicide to give a selected response. Assessments are generally based on mortality, but other criteria of toxicity such as suppression of growth or inhibition of seed production may be equally important when considering the practical use of the herbicides under test.

This method of measuring comparative toxicity is laborious and, although it gives accurate results, is little used by investigators in the field presumably because of the work involved. An alternative and much easier method of obtaining estimates of equi-effective doses is offered by the principle of the logarithmic spraying equipment announced by Pfeiffer, Brunskill and Hartley (1955). This equipment, which is described in detail elsewhere in the Proceedings is designed to spray large plots of about 30 yd in length. Bearing in mind that a pre-requisite of the technique is a reasonably uniform stand of plants, such a large plot, while being entirely suitable for many cultivated plants, raises considerable difficulties when applications to naturally varying stands of annual weeds are contemplated. The large plot also restricts the number of comparisons that can be made at a single site. For the research-worker, a small-scale version of the tractor-mounted sprayer produced by Messrs. Fisons Pest Control Ltd. is an obvious development of this new technique. This report describes the progress that has been made in the construction of a logarithmic sprayer for use in the field to spray plots 2.5 ft wide and about 9 yd in length.

Construction

Briefly, the equipment consists of a portable track, 30 ft long, on which travels an electrically-propelled trolley carrying the spraying unit. A general view of the equipment is shown in Plate 1.

The track itself is made from a light-alloy ladder cut into three sections, each approximately 10 ft in length to allow transport on a roof-rack fitted to a Land Rover. The track is mounted on four tubular steel trestles with adjustment for height provided by a telescopic mounting and adjustable legs. The sections are joined rigidly together by means of light-alloy plates, which are themselves firmly attached to the trestle; this gives a very rigid assembly, which remains surprisingly stable on uneven ground, and allows the track to be carried as a single unit from plot to plot. An insulated brass conductor is mounted centrally on the track to supply power to the trolley from a 24 volt battery via a sliding contact. The main frame of the ladder completes the circuit. The truck assembly weighs less than 100 lb and is easily moved about by two men.

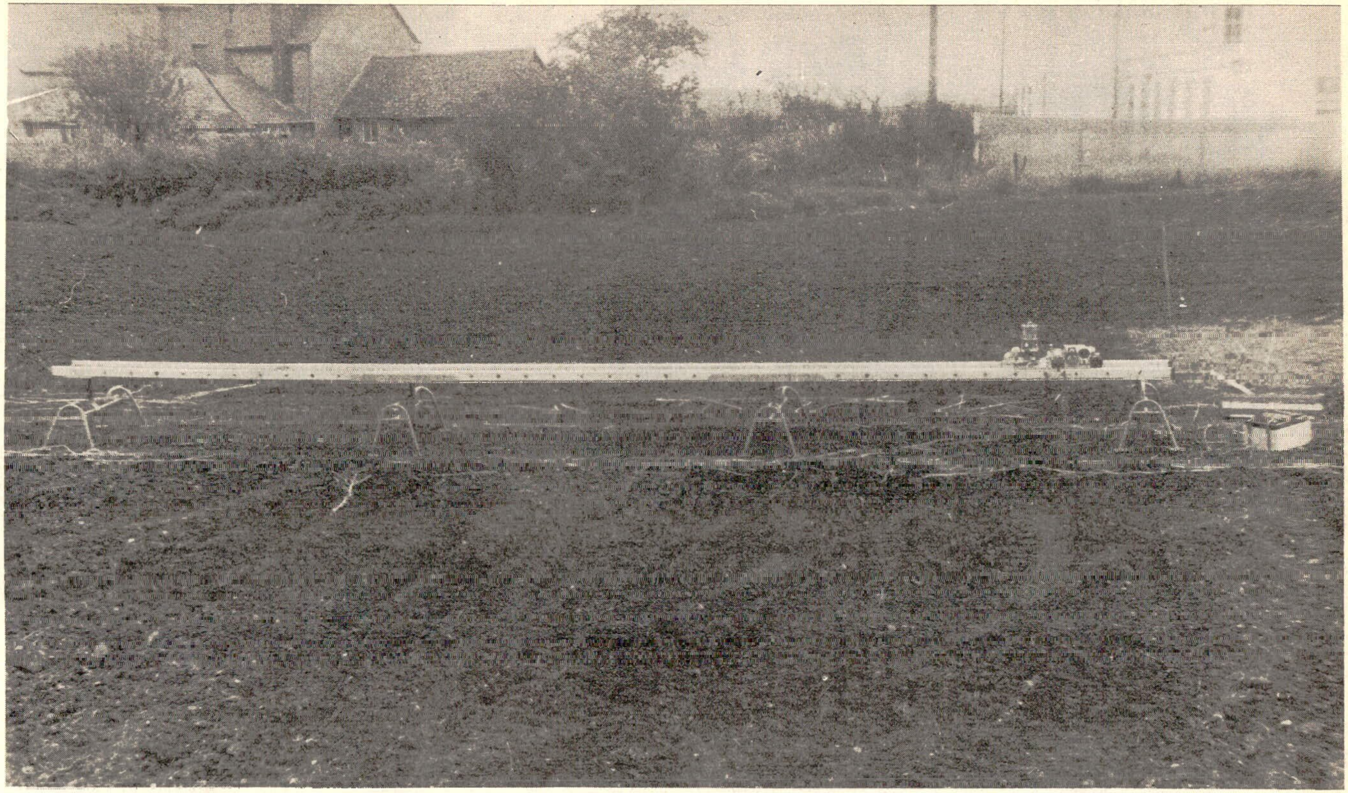

Plate 1

General view of logarithmic sprayer assembled and ready for use. The 24-volt battery on the right is normally carried in a vehicle.

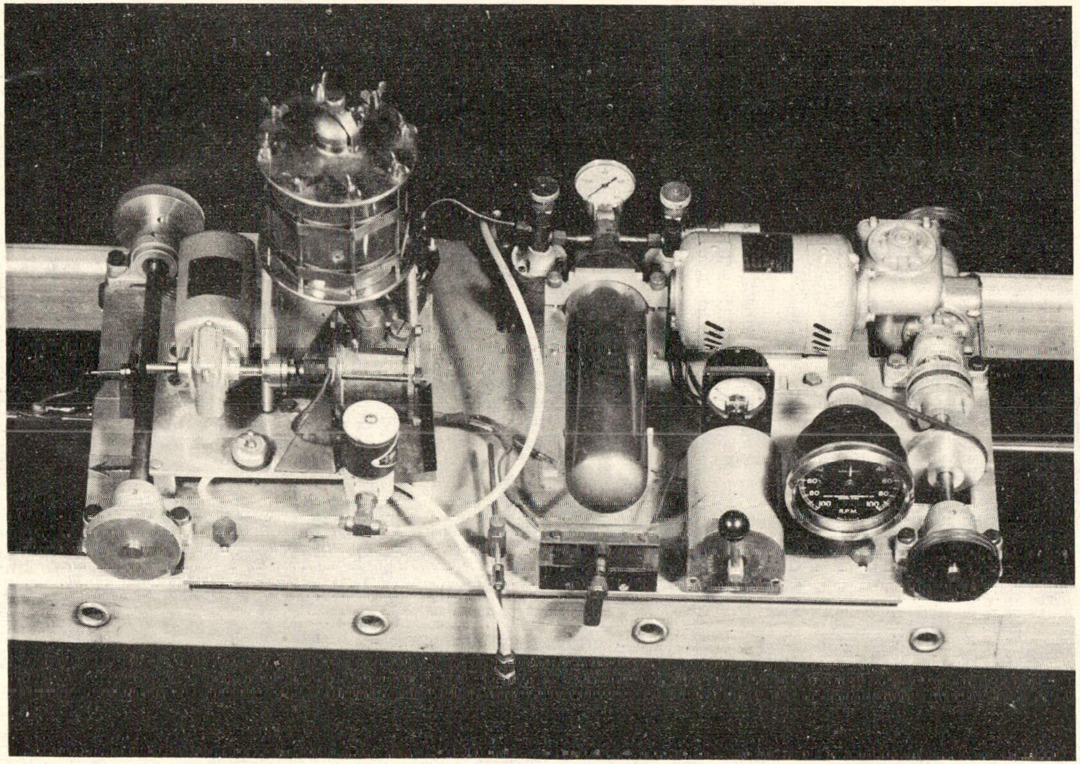

Plate 2

The spraying trolley. On the extreme left is the electrical pick-up, then the spraying unit consisting of two liquid containers, stirrer motor and magnetic valve. In the centre is the air pressure vessel in front of which is the trip switch actuating the valve. On the right is the propulsion motor and driving shaft with control switch, revolution indicator and ammeter. One spraying jet can be seen in the foreground. The quick-action coupling used when replenishing the pressure vessel can just be seen behind the propulsion motor.

The trolley (Plate 2) consists of an aluminium base-plate on which is mounted the spraying unit and ancillary equipment. It is propelled at a constant speed of 0.49 m.p.h. by a reversing shunt-wound motor coupled to two reduction gearboxes and giving a torque of 30 lb/in. on the driving shaft at 50 r.p.m. A ball-race is mounted horizontally under the base-plate at each corner with adjustable clearance between its periphery and the internal face of each main truck girder. This arrangement locates the trolley on the track and allows operation across slopes without affecting the speed of travel. The spraying unit consists of two liquid containers, an upper one of 780 ml capacity connected through a spring-loaded valve to a mixing-chamber of 144 ml. Inside the latter is a vane, which rotates at 120 r.p.m. to ensure thorough mixing of the two liquids. It is driven through a liquid-tight gland by an 0.1 horse-power electric motor. Pressure for spraying is provided by compressed air stored in a 45 in.^3 light-alloy pressure cylinder, which has a maximum working pressure of 750 p.s.i. Pressure is reduced by means of a pre-set valve to 30 p.s.i. Owing to the difficulty of working with such a high storage pressure in the field, it is probable that the small cylinder will be replaced by a larger one operating at about 120 p.s.i.

The liquid outlet at the base of the mixing-chamber passes directly into a valve operated by a solenoid. A switch on the side of the trolley is actuated by a trip, which is clamped to the track at any desired position. Polythene tubes of equal length convey the liquid to two jet-holders, which are adjustable for height and width.

Performance

The equipment has been designed to be operated by a team of two men. The time taken to dismount it from the Land Rover and to assemble it ready for spraying is about twenty minutes. As detailed marking-out of the experimental area into individual plots is not required, this assembly time compares favourably with the time required for marking out a conventional randomised plot experiment.

Calibration tests have been completed for two sizes of ceramic fan-jets (sizes 00 and 000). Jets matched for throughput and giving a similar performance across the fan are used and the dilution has been determined at measured points along the track. The results (Fig. 1) shows that a logarithmic decrease in concentration does in fact take place under the still air conditions of the tests. The volume-rates applied by these jets to the central and uniformly sprayed part of the swath are approximately 80 and 50 gal/ac respectively. The greater variation with the 000 jets is due to the production of large drops, which form at the edge of the ceramic discs and which are scattered intermittently into the spray. It is hoped that it will be possible to select individual jets that do not have this fault.

One of the limitations of the equipment in its present form is that because of the slow forward speed of the trolley, a high volume-rate is obtained with a droplet performance typical of a commercial low-volume sprayer. Another disadvantage is that the dilution-rate cannot be changed without altering the volume-rate. This difficulty could be readily overcome by having interchangeable mixing-chambers of various sizes to give any desired combination of dilution and volume-rates subject only to the limitations imposed by a restricted range of jet sizes.

Discussion

Mechanically, the prototype small-scale logarithmic sprayer described appears very promising as a workable piece of equipment. The main factor that seems likely to restrict its usefulness in the field is wind-drift. With such a small plot and with the rapidly changing concentration of the spray, drift of spray-droplets must be avoided at all costs. A windshield made of hessian to stretch the whole length of the track is under construction and will, it is hoped, prove effective.

The equipment has been designed principally for use in the field but it could also be of value for the rapid spraying of plants growing in pots placed at selected positions along the track. A number of doses of each chemical within a restricted dose-range could then be applied in a single operation.

Acknowledgement

The ideas and advice of many people have been incorporated into the design of this equipment and their willing help is gratefully acknowledged. In particular, the writer would like to thank Dr. G. S. Hartley of Messrs. Fisons Pest Control Ltd. and his staff for designing and building the spraying-unit and Professor G. E. Blackman for allowing the equipment to be built in the workshop of the University Department of Agriculture. This account would not be complete without acknowledgement of the enthusiasm and interest of Mr. P. I. Benham and Mr. F. Roach of the Department workshop and also of the help given by Mr. R. J. Chancellor who carried out the calibration tests.

Reference

(1) PFEIFFER, R., BRUNSKILL, R. T. and HARTLEY, G. S. (1955) Nature, Lond. 176, (4479), 472-473.

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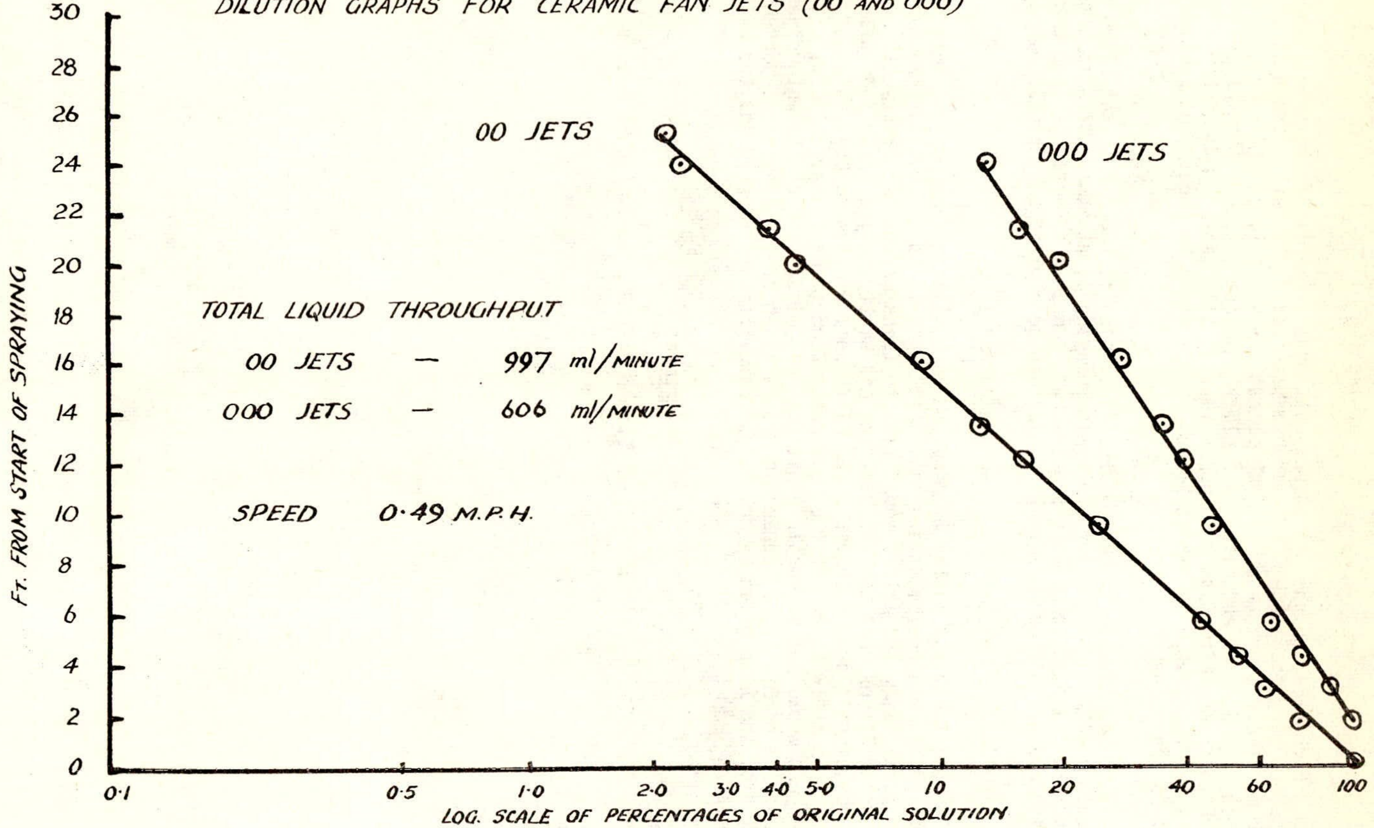
LOGARITHMIC SPRAYER

DILUTION GRAPHS FOR CERAMIC FAN JETS (00 AND 000)



TOTAL LIQUID THROUGHPUT

00 JETS — 997 ml/MINUTE

000 JETS — 606 ml/MINUTE

SPEED 0·49 M.P.H.

DISCUSSION ON THE PREVIOUS TWO PAPERS

Mr. R. J. Chancellor

Drift is an extremely important factor with logarithmic spraying. What precaution does Dr. Hartley take to avoid this?

Mr. R. C. Amsden

Spraying operations carried out under field conditions are, more or less, subject to errors caused by drift. The saving in time resulting from using the logarithmic sprayer permits laying down more field plots when the weather conditions are suitable. Thus, one is better able to avoid spraying on windy days.

Mr. R. F. Norman

These two reports show that a start has been made on investigating the methods of application and indicates how better equipment may be produced. I feel that under the present circumstances more time should be given to the consideration of applying these herbicides, since it is obviously of little use having herbicides if they cannot be applied correctly. The particular advantage of the logarithmic sprayer is that is is fitted with commercial nozzles and operates on a field scale under conditions which are as near as possible to those associated with field spraying. These results may be regarded as true field results.