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A REVIEW OF PROCEDURES AND TECHNIQUES FOR TESTING GROUND CROP SPRAYERS

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INTRODUCTION

For many years the national machinery testing stations of several countries, notably Britain, Denmark, Norway, Germany and Ireland, have been testing sprayers. The only complete test procedure that has been published is that of Hebblethwaite and Richardson (1961) of the National Institute of Agricultural Engineering in England (N.I.A.E.). A standard for the performance of sprayers has been published by Biologische Bundesanstalt fur Land und Forstwirtschaft (1968) in Germany, but this does not deal with the method of test.

When sprayer testing commenced in Ireland in 1965, the procedure was based on that of the N.I.A.E. Since then, eleven sprayers have been tested, and some of the procedure has been changed in the light of the results obtained. The most important changes have been in methods of assessing the lateral and longitudinal distribution of spray, the efficiency of the agitation system, and the pump and nozzle tests. This paper reviews these developments, and discusses the present procedure, and the most significant results of the tests. The feasibility of an international standardised procedure for testing is considered.

LATERAL DISTRIBUTION OF SPRAY

Equipment and procedure

The equipment and procedure used to measure the spray patterns of individual nozzles and of the whole boom have been described by Rice (1967). The spray patternator can be adapted to measure the pattern of a single nozzle in 1 in (25.4 mm) sections as required by British Standard 2968 (1958), or the pattern from a spray boom in 2 in (50.8 mm) sections. The patternator is 8 ft (2.44 m) wide, and can be moved laterally, so the patterns of booms up to 32 ft (9.75 m) wide can be obtained in four movements.

The length of the patternator sections at 3 ft (0.91 m) has been a limiting factor. For booms with hollow-cone nozzles, a length of 4 ft (1.22 m) would be desirable.

The limits set out in B.S. 2968 were used in initial sprayer tests to check the nozzle outputs and patterns. This system of limits has several unsatisfactory features:

1. It confines itself to nozzles with two specific shapes of spray pattern.
2. It gives little indication of the evenness of spread one can expect when the nozzles are fitted to a boom.

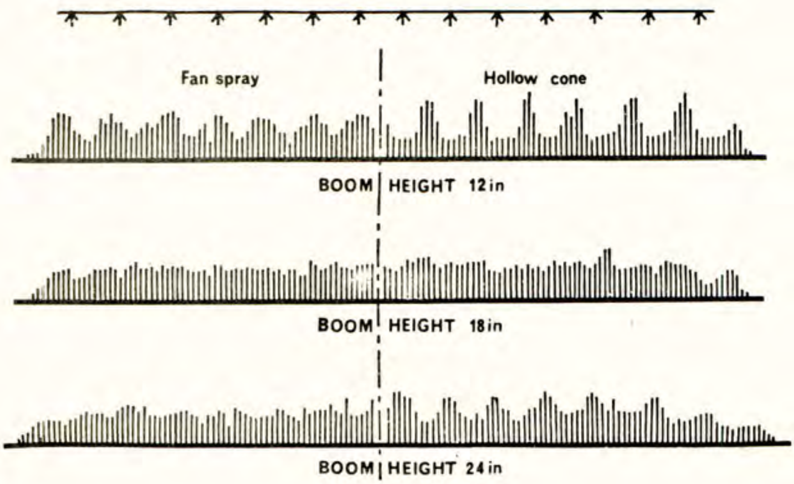
3. It demands a higher standard of accuracy from nozzles with triangular spray patterns than from those with trapezoidal patterns.

A new limit system has been proposed by Rice and Connolly (1969) which overcomes these problems to some extent. With this system, the evenness of spread from the boom could be predicted with reasonable accuracy from the limits set for the nozzle patterns, regardless of the type of nozzle. The limits could also be used to grade nozzles, i.e. close limits could be set for nozzles suitable for very accurate spraying and wider limits could be set for more general- purpose nozzles.

A better limit system for checking nozzles would enable a more accurate estimation of the variance of the boom spray pattern to be made. Nevertheless, it is still useful to measure the spray pattern of the whole boom. First, the effect of boom height on the evenness of spread can be clearly shown (Fig. 1). Since one cannot maintain the boom exactly at the right height all the time, this can be an important factor in the assessment of a sprayer. Second, the cumulative effect of such factors as pressure drop along the boom, and inaccurately spaced or aligned nozzles can be shown. Items such as the outward-spraying nozzles fitted to the ends of the booms of some Continental sprayers can also be evaluated. The equipment required for this test is elaborate, but the results can make it worthwhile.

Figure 1

Distribution patterns at three boom heights, comparing hollow cone and fan spray nozzles



Results

The outputs of virtually all the nozzles tested were within the limits specified in B.S. 2968 and in the German Standard. Boom patterns were measured at the recommended boom height, and at heights 6 in (152 mm) above and below this value. The coefficients of variation of each pattern was calculated, and some typical results are given in Table 1. The most notable feature of the results has been the greater accuracy of fan-spray nozzles compared with hollow-cone. The hollow-cone nozzles were usually more severely affected by changes in the boom height, but this depended on the nozzle spacing and the shape of the nozzle patterns. Scarcely any of the boom patterns were within the limits of ±15% set in the German Standard.

Table 1

Coefficients of variation of boom spray patterns

Nozzle type	Sprayer	Nozzle size	Boom height (in)		Coefficient of variation (%)
Fan-spray	A	1	12	(305 mm)	29
			18	(457 mm)	14
			24	(610 mm)	15
		2	12		45
			18		13
			24		13
	B	1	12		18
			18		9
			24		9
		2	12		24
			18		14
			24		16
Hollow-cone	C	1	18		36
			24		23
			30	(762 mm)	28
		2	18		40
			24		18
			30		17
	D	1	15	(381 mm)	27
			20	(508 mm)	25
			25	(635 mm)	24
		2	15		28
			20		27
			25		23

LONGITUDINAL DISTRIBUTION OF SPRAY

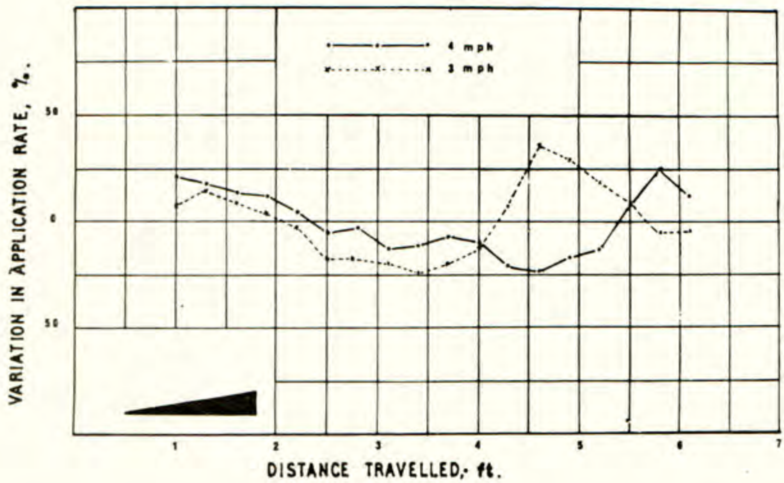
Equipment and procedure

Spray distribution in the direction of travel is affected mainly by vertical and horizontal vibration of the boom. It was measured by collecting the spray in a series of trays placed underneath the boom and measuring the quantity of spray in each tray (Rice, 1967). To simulate the effect of rough ground, one wheel of the tractor was driven over a wedge 15 in (381 mm) long, 2 in (51 mm) high. The tests were carried out at 3 and 4 mile/h (4.83 and 6.44 km/h).

The results of these tests have given rise to doubts about its value. The method of collecting and measuring the spray was satisfactory. However, with two sprayers, the variations in application rate caused by the bump were greater at 3 than at 4 mile/h (Fig. 2). This raises the possibility that even greater variations might have been recorded at lower or intermediate speeds.

Figure 2

Longitudinal spray distribution at 3 and 4 mile/h



Since only one shape of wedge is used as a bump, and the test is carried out at only two forward speeds, it could be regarded more as a spot check than a thorough assessment of the effect of speed and ground roughness on spray distribution. A more satisfactory test could be devised by replacing the wedge by an artificial track such as that at N.I.A.E. (Matthews, 1967).

Results

The results obtained show the importance of this type of test. Variations in application rate from 55% to 155% of the mean have been recorded at the Agricultural Institute, Carlow (1966). With the improvement that has taken place in sprayer nozzles far greater variations in distribution are now being caused on many sprayers by boom vibrations than by imperfections in the nozzles. This aspect of sprayer design is in urgent need of attention.

EFFICIENCY OF AGITATION

Equipment and procedure

The purpose of this test was to examine the machine's ability to prevent wettable powders settling to the bottom of the tank.

Copper oxychloride powder was mixed to a paste in a small quantity of water. The tank was half-filled, using the self-filling system where available, and the paste was then added. Filling was then completed, and the agitation system was operated for 5 minutes. During this period, samples were taken at one-minute intervals from the supply line to the boom. At the end of this period, the sprayer was set to deliver its highest volume. About 10 samples of the spray were collected from the boom as the tank emptied. The concentration of copper oxychloride in each sample taken during the test was measured by quantitative analysis using the following method.

A 25 ml sample of the spray was taken. Five ml of dilute nitric acid (1:1) was added to dissolve the copper. The excess nitric acid was neutralised with 3N sodium hydroxide (about 8 ml) until the first trace of permanent precipitate formed. Five ml of 3N acetic acid was then added to dissolve the precipitate. About 1 g of potassium iodide was added. The liberated iodine was titrated against 0.5N sodium thiosulphate, a 1% solution of sodium starch glycollate being used as an indicator.

At the end of the spraying period, the quantity and concentration of copper oxychloride remaining in the tank was measured.

The test was designed to simulate difficult operating conditions, with a careful operator. One would normally have a longer period than 5 minutes available for agitation while travelling from the water supply to the field. There would also be other periods, e.g. at headland turns, when spraying would be interrupted, and these could be used for agitation.

The results of this test obviously depend to a large extent on the properties of the wettable powder used, and it would be necessary to specify these completely.

The method of measuring the copper concentration of the samples is slow, requiring 10 to 15 minutes per sample. It has the advantage that it can be carried out with standard laboratory equipment and reagents and with a minimum of technical skill.

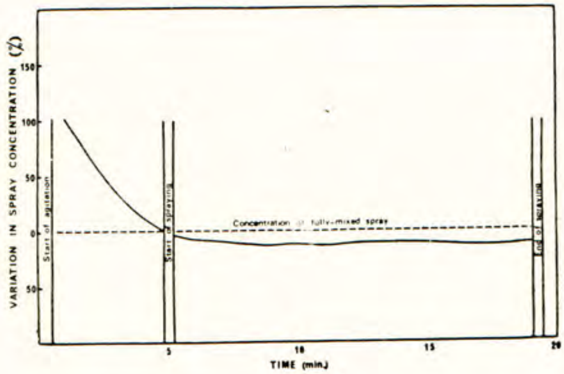
Results

All the sprayers tested had hydraulic agitation systems. On most of them, the return from the pressure regulator was connected to the bottom of the tank. With all these sprayers the variation in concentration of the spray was very small; it was well within the limits of $\pm 15\%$ set in the German standard.

On two sprayers tested, the overflow was returned to the top of the tank. On these machines the samples taken during the 5-minute agitation period had very high concentrations (Fig. 3). However, once the chemical was mixed, it did not settle out appreciably during spraying, and the amount of chemical left in the bottom of the tank was not significant.

Figure 3

Variation in spray concentration during filling and spraying



SPRAY PENETRATION

Equipment and procedures

The procedure used was the same as in the N.I.A.E. tests. Qualitative and quantitative assessments of coverage and penetration were carried out in cereals and potatoes. In cereals, spray samples were collected on dishes placed on the ground. In potatoes, leaf samples were taken from the sprayed crop at three levels. Nigrosine dye was used for quantitative measurements, and a fluorescent dye for the qualitative assessments. Each treatment was replicated six times.

Results

Three sprayers with a range of droplet sizes, pressures and nozzle types were compared in cereals at 20 gal/acre (225 l./h) and potatoes at 40 gal/acre (449 l./h) (Table 2).

Table 2

Penetration test (a) Cereals at 20 gal/acre

Sprayer	Nozzle type	Pressure lb/in^2	(kN/m^2)	Droplet SMD	Spray recovered at ground level (% of total amount sprayed)
A	Hollow-cone	78	(538)	200	27
B	Fan	40	(276)	220	33
C	Hollow-cone	70	(483)	290	40
					Significance: F = 4.26 (NS)

(b) Potatoes at 40 gal/acre

Sprayer	Nozzle type	Pressure lb/in^2	(kN/m^2)	Droplet SMD
A	Hollow-cone	68	(469)	260
B	Fan	40	(276)	260
C	Hollow-cone	70	(483)	420

The cereal crop was about 10 in (0.25 m) high when sprayed. The coarser spray appeared to penetrate the cereal foliage better, but the differences in recovery were not significant (Table 2a). The results were similar to those in N.I.A.E. tests (Hebblethwaite and Richardson, 1966).

In potatoes, the difference between machines was small, and no significant differences were obtained.

PUMP AND NOZZLE WEAR

Equipment and procedure

As in the N.I.A.E. tests, a separate durability test was carried out on the pump and nozzles. In the first series of tests, the pumps were run for 500 hours recirculating a 1% copper oxychloride suspension. In later tests a range of spray chemicals was used (Table 3). The pump was run continuously, so the test was completed in about 3 weeks. The flow-rate was checked at 12-hour intervals with a rotameter flowmeter. Cooling coils were needed to control the liquid temperature.

The 500-hour test period seems long enough to detect any serious faults in the pumps, but still allows the tests to be carried out quickly. The main problem is the selection of a suitable range of chemicals for test. One can either select a range that reflects current usage of chemicals, or maintain the same range for comparative purposes, even though some of the chemicals may be out-dated. The former seems the more reasonable alternative.

In conjunction with the pump tests, nozzle wear was assessed by circulating the chemical through the nozzles and measuring the change in output. Three nozzles of each size supplied were tested.

Table 3

Timetable for pump and nozzle durability tests

Period (hr)	Fluid	Pressure
0 - 10	Water	0
10 - 50	Water	Normal working pressure
50 - 150	Copper oxychloride 1%	" " "
150 - 250	Mancozeb	" " "
250 - 350	Simazine	" " "
350 - 450	MCPA	" " "
450 - 500	Water	" " "

Nozzles are tested for 300 hours: 100 hours each with copper oxychloride, mancozeb and simazine.

Results

Of 8 diaphragm pumps tested, all completed the test without any serious damage or loss of output. The five roller-vane pumps tested gave more variable results. Two completed 500 hours without needing any more than minor repairs, but the other three were badly worn after 200 hours.

The outputs of brass nozzles increased rapidly with use (Table 4). None of the other materials showed any serious wear.

Table 4

Comparison of the wear of nozzles made of different materials

Nozzle material	Nozzle size	Increase in output after 300 hours (%)
Ceramic	1	7
	2	8
Stainless steel	1	0
	2	0
Brass	1	63
	2	49
Plastic	1	2
	2	9
	3	0
	4	1

RATE OF WORK

Procedure

Many factors other than the sprayer performance affect rate of work, the two most important being the application rate and the distance to the water supply. Operating conditions therefore, need to be standardized to facilitate comparison of the results obtained with different sprayers. In Table 5, which includes typical results for low to medium volume sprayers, a maximum spraying speed of 4 mile/h (6.44 km/h) and a travelling time of 20 minutes per fill have been assumed. The times for each part of the operation are given, so that the effect on rate of work of changing any factor can be easily evaluated.

Results

The results obtained in tests showed that a high proportion of the time was being spent travelling to and from the water supply. The time required to turn on headlands in rowcrops was also very high, due to the necessity to dismount from the tractor twice during the turn to fold and open the boom (Table 5).

Table 5

Rate of work of sprayers

(a) in cereals at 20 gal/acre (225 l/ha)

Sprayer	Time spent (min/acre)			Rate of work	
	Spraying	Filling	Travelling	acre/hr	(ha/hr)
A	6	5	9	3.0	(1.2)
B	5	3	5	4.8	(1.9)
C	4	2	5	5.6	(2.3)

(b) in rowcrops at 40 gal/acre (249 l/ha)

Sprayer	Time spent (min/acre)				Rates of work	
	Spraying	Turning	Filling	Travelling	acre/hr	(ha/hr)
A	12	5	10	17	1.3	(0.54)
B	6	5	6	9	2.2	(0.89)
C	4	5	4	9	2.6	(1.1)

CONCLUSIONS

For measuring the lateral distribution of spray, it is desirable to measure the spray pattern of the whole boom. An improved standard for nozzle patterns is also required.

Assessment of the effect of rough ground on longitudinal distribution is very important, since it is frequently a source of great inaccuracy. For a thorough assessment, the use of an indoor track to produce a ride similar to field conditions would be desirable.

Techniques for assessment of efficiency of agitation and spray coverage and penetration are satisfactory, but with most modern sprayers and chemicals no significant differences are likely to be found.

Rate of work is easily measured, but the method of presenting the results needs attention. It should permit comparisons to be made between different sprayers and it should also enable the effect of various factors such as boom width, tank size, pump output and self-filling time to be evaluated.

The development of equipment for sprayer testing is now well advanced, and the establishment of a standardized test procedure should be possible. Standard test procedures for tractors, fertilizer spreaders and combine harvesters have already been drawn up under the aegis of O.E.C.D. (1966). The purpose of these codes is "to facilitate trade by enabling an importing country to accept with confidence the tests carried out in another country". Other reasons for adopting a standard test code are:

1. The avoidance of duplication of work by national testing stations.

2. An increase in the volume of useful information available on the performance of machines.

3. Ultimately an improvement in the quality of machines, by exerting pressure on manufacturers to meet a required standard.

The sprayer is one of the most suitable of farm machines for standardized testing, since its performance is relatively unaffected by operating conditions and the equipment and facilities required are fairly simple. While some aspects of sprayer testing need more attention enough work has been done to enable a useful standard test procedure to be drawn up. The techniques described here, together with those described elsewhere, could provide the basis for this procedure.

References

Agricultural Institute, Carlow, Republic of Ireland (1966) Test Reports Nos. 21, 22, 25, 41, 42, 43, 44, 45, 51

Biologische Bundesanstalt fur Land und Forstwirtschaft, Braunchweig (1968). Anforderungen an Feldspritzgerate

British Standards Institution (1958) Hydraulic spray nozzles for insect, fungus and weed control and for like purposes. Br. Stand. Spec. 2968 (1958)

HEBBLETHWAITE, P., RICHARDSON, P. (1961) Procedures for sprayer testing. J. Proc. Instn. agric. Engrs, 17 (2) 51

HEBBLETHWAITE, P., RICHARDSON, P. (1966) Spray recovery in cereals. Weed Research, 6 (1) 84

MATTHEWS, J. (1967) Ride comfort for tractor operators: IV Assessment of the ride quality of seats. J. agric. Engng Res. 11 (1) 44

RICE, B. (1967) Spray distribution from ground crop sprayers. J. agric. Engng Res. 12 (3) 173

RICE, B., CONNOLLY, J. (1966) Quality control limits for the distribution patterns of sprayer nozzles. J. agric. Engng Res. 14 (4) 313

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THE ADVANTAGES OF FULL CONE JETS FOR SPRAYING HERBICIDES

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INTRODUCTION

An even distribution is desirable for all pesticides applied, but it is of major importance for selective herbicides which must kill the weeds and not harm the crop. However, present equipment gives rise to considerable local variation. In spite of this, good results are obtained due to the high selectivity of the herbicides. If in practice 10 kg/ha of a certain herbicide are used and needed, local variations will occur from, e.g., 3 to 30 kg/ha or 0.3 to 3 time the average, the minimum giving a satisfactory weed control and the maximum no damage to the crop. When this variation is reduced to between one half and double the average, the required dose can be decreased from 10 to 7 kg/ha, the local minimum being 3.5 and the maximum 14 kg/ha. This approximately reflects what is done at present and what is possible in practice.

We aim, of course, at an even distribution in the field both across and in the moving direction. In our studies the crosswise and lengthwise distribution were studied separately. The distribution across depends on the spray pattern (liquid distribution) of the nozzles, their place on the boom and its height. The lengthwise distribution is affected by the swinging of the boom and the width of the zone covered by the nozzles.

In addition to the distribution the occurrence of drift can be a problem. Drift of foliage-applied herbicides often causes damage to adjacent crops. The risk involved is minimised if

(a) the spray contains only a minimum of very fine droplets

(b) the height of the spray boom is low

(c) the nozzles are directed straight forward.

All these points have been covered by investigations at IBS. Results show that in practice good full cone jets give a more even distribution and are less risky for drift damage than the best hollow cone and fan jets.

EXPERIMENTAL METHODS

Liquid distribution

(a) This was determined by spraying water with nozzles at rest on a patternator, a slightly slanting board of 50 mm wide troughs.

(b) By spraying 0.3% solution of nigrosine, a black water-soluble dye, on polystyrene foam sheets (with nozzles both at rest and moving) or on transparent polythene sheet (only when moving).

Strips or squares cut from these sheets were washed in a certain quantity of water, in which the nigrosine dissolves completely because it is not absorbed by the plastics. The volume of liquid sprayed on each strip or square is determined by measuring the nigrosine concentration in the water extract with a nephalometer.

This method is also used in determining the variability in deposition when spraying in the field. Then the nigrosine content of squares of, e.g., 10 cm, cut from the lightest and the darkest places of a sprayed foam sheet indicate the minimum and the maximum rate of application.

Droplet size distribution

This was determined by spraying 0.3% nigrosine solution on transparent polythene sheet. It was found that

(a) even large drops do not split when they drop on this sheeting (Fig. 1).

(b) the diameter of the black stains remaining after drying is independent of the the height of dropping

(c) there is a direct relationship between stain diameter, drop diameter and drop volume. This was determined (Fig. 2 and 3).

Pieces of sprayed polythene sheeting were projected at 20-fold enlargement in order to allow grouping of the drop in 15 classes differing by a factor of $\sqrt{2}$. The mean mean stain diameter of the smallest class was 62.5 µm corresponding to a mean drop diameter of 51 µm and a mean drop volume of 7×10^{-5} mm^3. Of the greatest class the mean stain diameter was 8 mm corresponding to a drop diameter of 8 mm and a mean drop volume of about 33.5 mm^3.

The distribution over the 15 classes was calculated for the number of drops and for the volume they represented.

Although nigrosine affects the surface tension and, therefore, the drop size and the liquid distribution, this is not a disadvantage, because in this respect pesticide sprays probably differ more from pure water than from 0.3% nigrosine solution.

RESULTS

Nozzle characteristics

The spraying pressure affected the performance of the nozzles that were investigated in that (a) common swirl nozzles gave a finer spray and a wider hollow cone at increasing pressure, and (b) full cone nozzles produced about the same drop size distribution or an even coarser spray at increased pressure, whereas the spray cone was wider. Compared to hollow and full cone nozzles the fan nozzle tested showed a wider drop size distribution.

Full cone nozzles produce a larger mean drop size and are therefore less susceptible to drift than hollow cone nozzles of the same capacity.

Figure 1

Stains from drops of 2.64 mm diameter, containing nigrosine, falling from different heights onto polythene sheet

FIG. 1

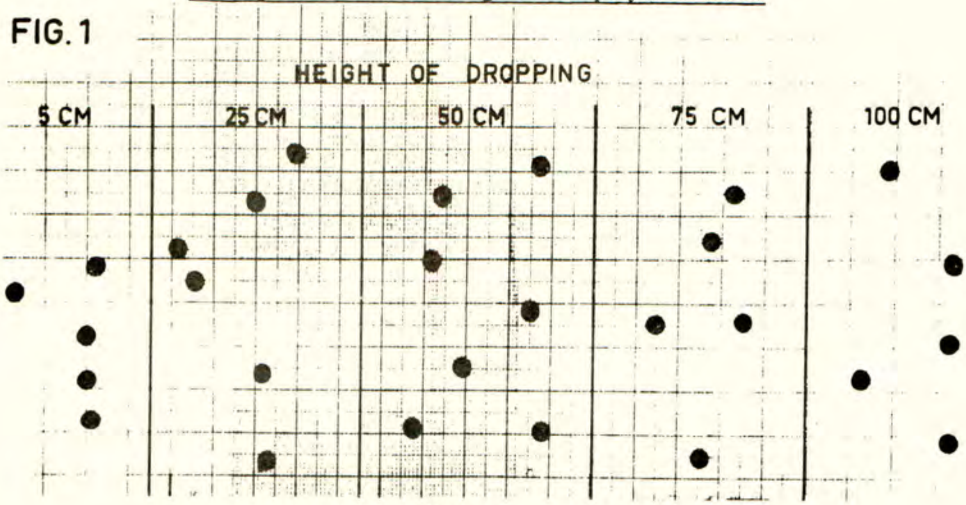


Figure 2

Stain sizes from differently sized drops on polythene sheet

FIG. 2

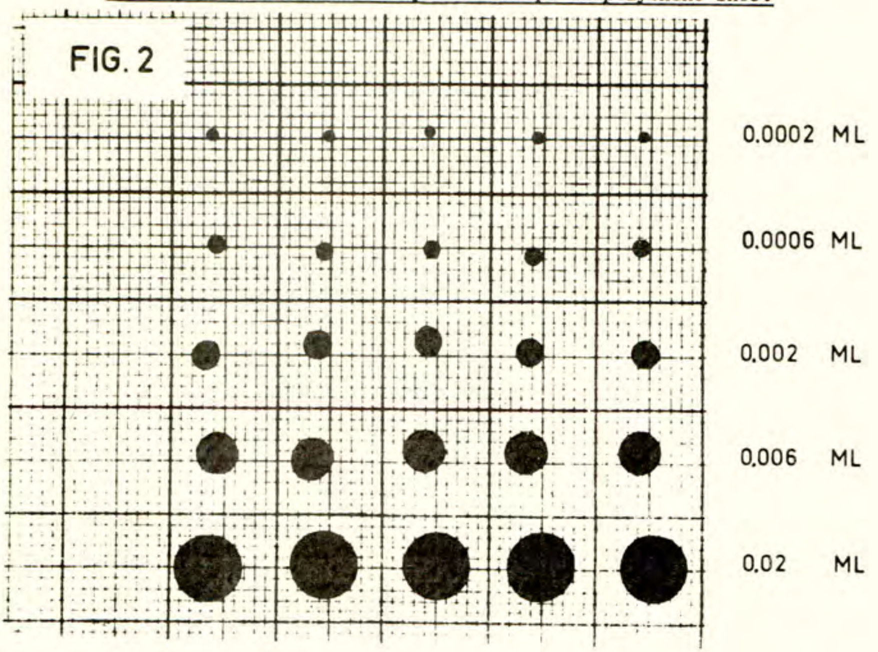


Figure 3

The relationship between drop diameter (ø drop), stain diameter on polythene (ø spot), and drop volume

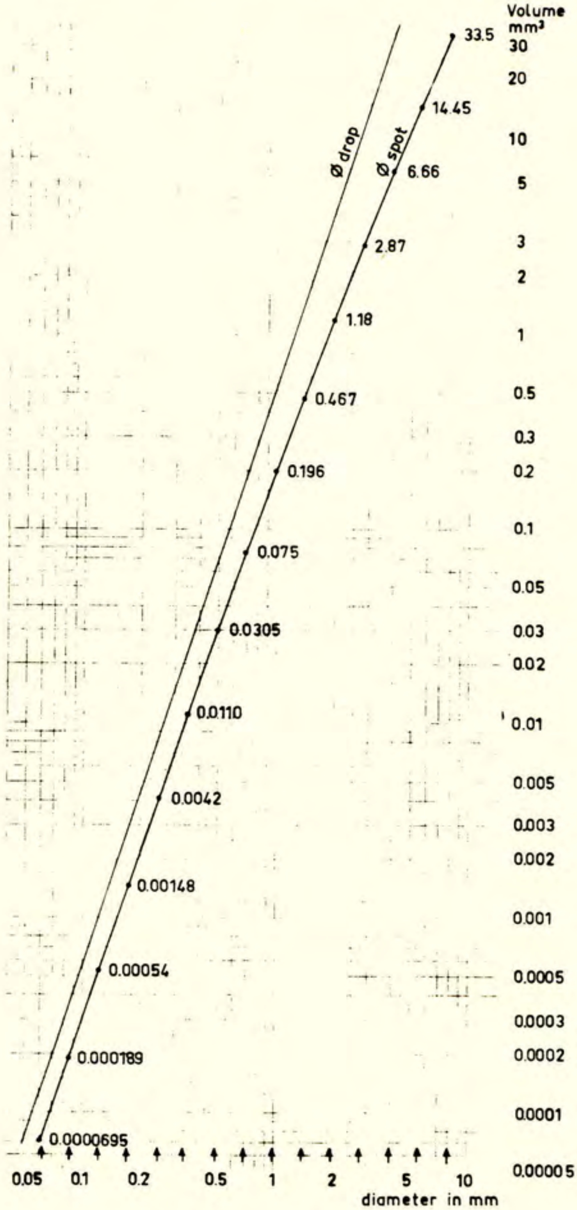


Figure 4

Patterns on a 50 mm patternator from 3 types of nozzle at different heights

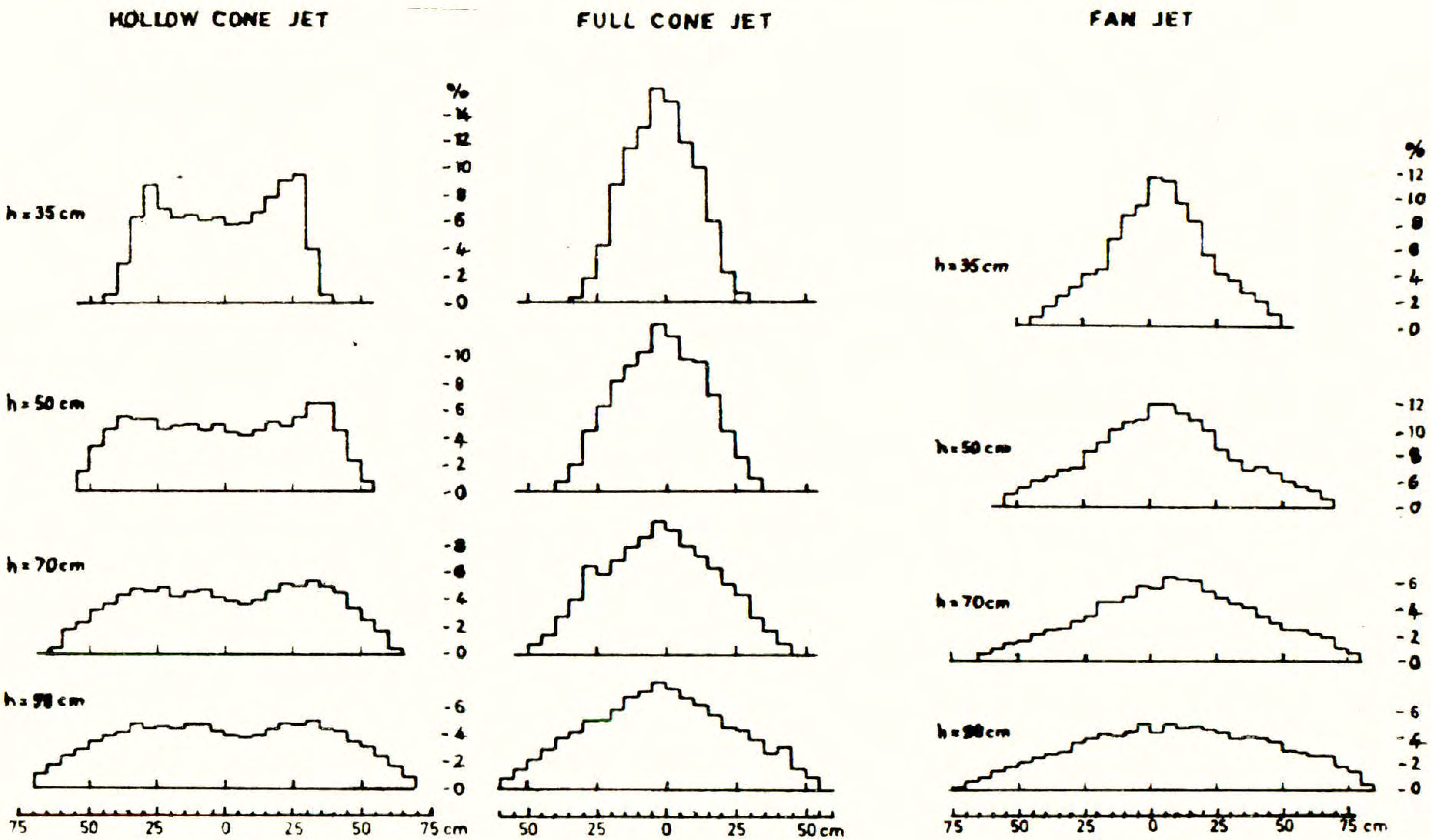


Figure 5

Patterns from moving nozzles

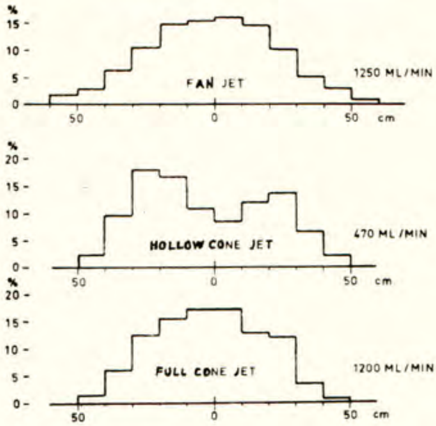
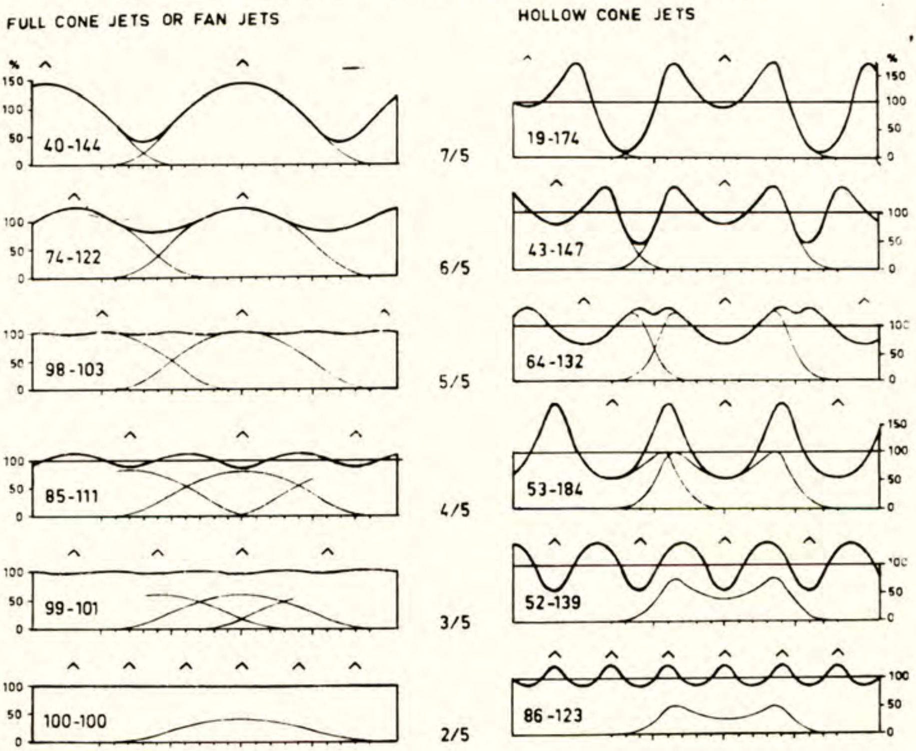


Figure 6

The effect of various degrees of overlap on nozzle pattern



Lateral distribution under a spray boom.

(a) Hollow cone nozzles are unsuitable on account of their doubly peaked spray pattern at rest (Fig. 4), this is even more pronounced when the nozzle is moving (Fig. 5).

(b) Full cone nozzles and fan nozzles with a single peak to their spray pattern are better because of their pattern characteristics when overlapped (Fig. 6).

Longitudinal distribution from a spray boom.

(a) Fan nozzles are unsuitable because they cover only a narrow band of ground which moves with a velocity directly related to the unavoidable swinging of the boom.

(b) Full and hollow cone nozzles are much better because they cover a wide zone which to some extent evens out the effect of the swinging of the boom.

Boom movement

The movements of the boom of a tractor-sprayer in operation were filmed and analysed. For this purpose the end of the 6 m boom was equipped with a light bulb connected to the battery of the tractor.

It was found that the actual horizontal velocity of the end of the boom varied from -1 to +3 times the normal tractor speeds of 4 - 7 km/h (2.5 - 4.4 mile/h). Fig. 7 shows the effect on the movement of the end of the boom of driving one side of the tractor over a 50 mm obstacle at two speeds. Extremes of forward velocity are given together with a plot of the position of the boom end at fixed intervals. This shows the need to counteract the swinging of the boom in the horizontal direction by the use of a construction specially designed to do so. Fig. 8 shows the behaviour of the end of the boom on three different sprayers, mounted, in turn, on the same tractor, when one rear wheel passed over the same obstacle. Table 1 gives derived data on the movement of the boom at a distance of 6 m out from the centre line.

Table 1

Movement of points 6 m along the boom of three sprayers as a rear tractor wheel passed over a 50 mm obstacle

Sprayer		A	B	C
Boom length, m		6	7.5	9
Tractor speed, m/s		1.35	1.17	1.11
Boom speed at 6 m out, m/s				
	minimum	-0.97	-0.53	0.72
	maximum	3.38	1.75	1.77
Ratio of boom speed to tractor speed				
	minimum	-1.71	-1.45	-0.35
	maximum	1.53	0.50	0.59
Limit of vertical movement, mm		800	300	190

The resultant variation in deposition using 0.3% nigrosine solution on snow-covered turf, has been recorded qualitatively by photography. Quantitative analysis from nigrosine deposits on foam sheeting are to be made in order to relate the boom movement to the deposition from different types of nozzle.

Figure 7

Movement of the end of a sprayboom as the tractor passes over an obstacle, at two speeds

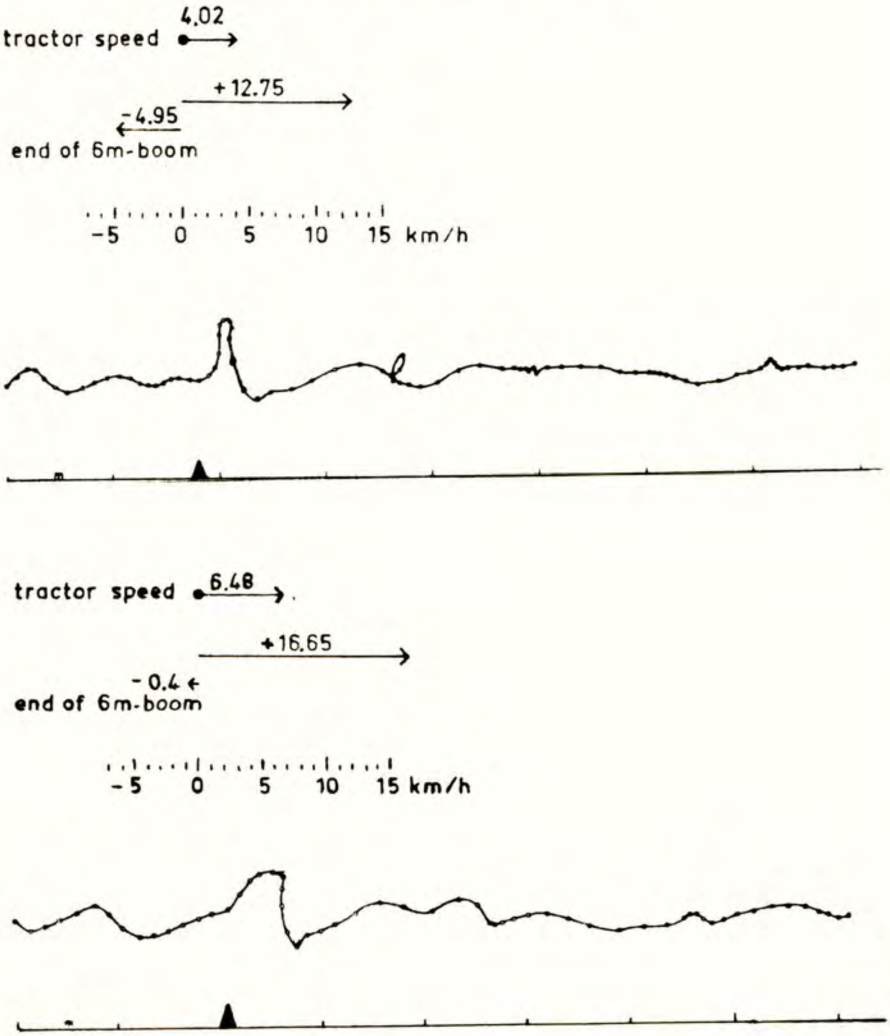
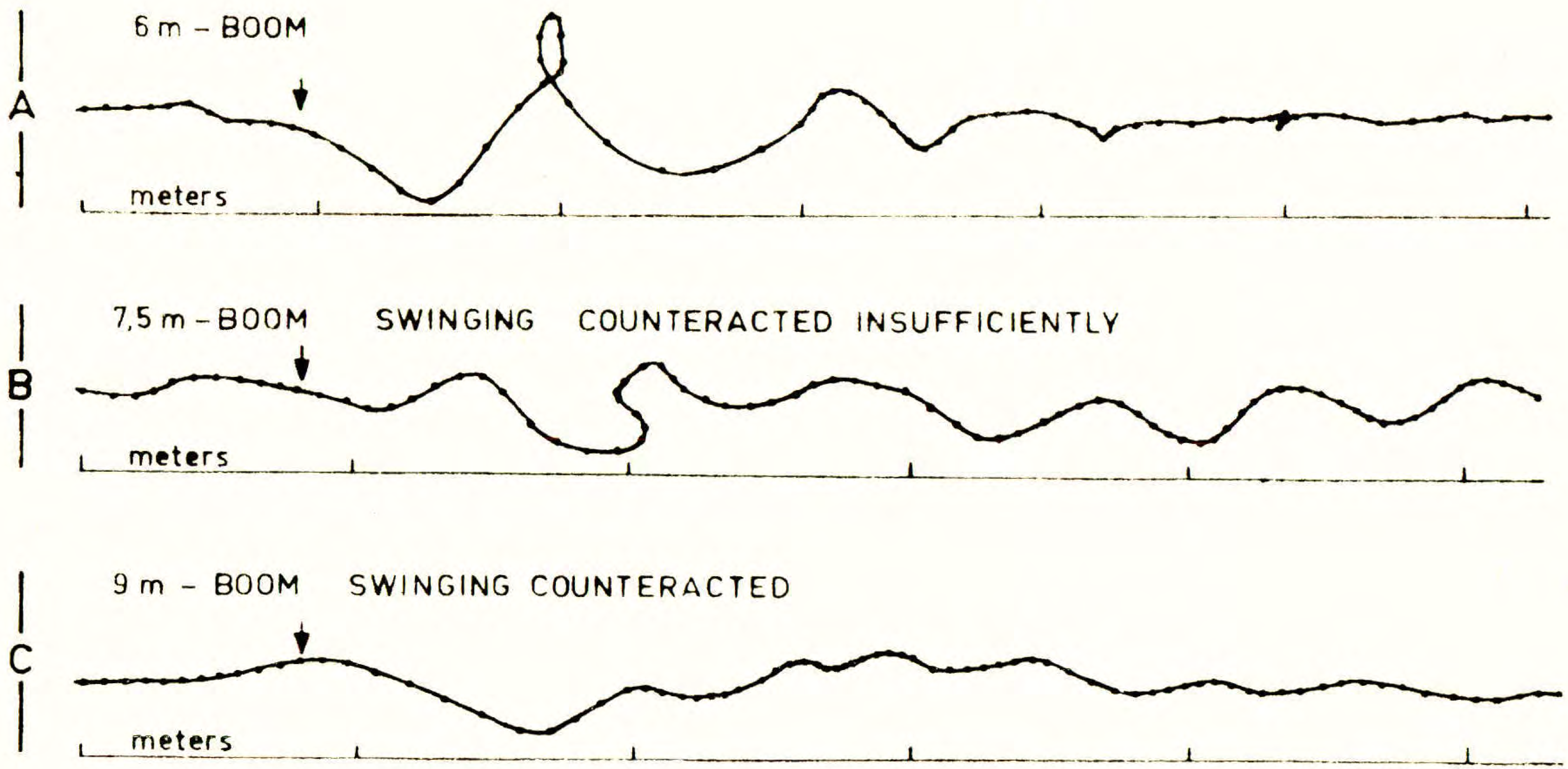


Figure 8

<u>Movement of the left boom of each of three sprayers as the right rear tractor wheel passed over a 50 mm obstacle (points at 1/16s intervals)</u>



Remarks by A. NORDBY in opening discussion on

THE PERFORMANCE OF FARM SPRAYERS

I have been asked to introduce this discussion and I will here try to look at the problems from a practical point of view. The largest quantity of the chemicals used in plant protection in Europe is still distributed from crop sprayers equipped with spraybooms. Basically, the crop sprayers have been more or less the same for the last 10 years. I think that crop sprayers will be the main equipment in plant protection in Europe for the next 10 years too, but, I hope, not without improvement.

Of course we have some new designs, new materials and so on. The equipment is more easy and convenient to use than it was some years ago. But what about the quality of work of the equipment? Do we know the quality of work we are attaining with the crop sprayers today? I am afraid not. The National Institute of Agricultural Engineering in England made a survey in 1967 of 26 sprayers. The distribution measurements carried out gave a coefficient of variation up to 78.3%. I think that we should investigate the quality of work we are getting with our sprayers today. I have a feeling that we are sometimes using doses so large that the quality of work does not matter very much.

In Norway, at the Norwegian Institute of Agricultural Engineering, we have carried out some trials with spray booms giving different distribution at the actual driving speed. Coefficients of variation (in %) of measurements in 50 mm wide channels were approximately 10, 35 and 55. The nozzles were mounted either in one row on the same sprayboom or every second nozzle pointed forwards and backwards so that we got 45 and 90° between the two nozzle rows. The trials were carried out spraying weeds in cereals. For the three boom arrangements and different distributions it was difficult to find any difference between treatments when we used half of the dose recommended in practice. When the spraying was carried out at the three leaf stage of the cereals, booms with nozzles mounted in two rows gave better results than booms with the nozzles mounted in one row.

I think it should be possible to improve the spray distribution from booms without doing much basic research work, and I would like to make the following suggestions:

1. In the future, distribution measurements, no matter whether in the laboratory or in the field, should be made at the actual driving speed.

2. The spacing and mounting of the nozzles should give a distribution that is less dependent on the boom height, at least between 350 and 600 mm, than for many of the boom types used today. The coefficient of variation should be less than 15% within these height limits and at working pressures from 2 to 10 kg/km^2 ($200 - 1000\ kN/m^2$).

3. The construction of the boom and the mounting on the sprayer should give a more stable boom height during spraying.

4. If the working width is 10 m or more, the boom should only be used in level fields. On uneven ground and for larger working widths the boom could have some means at the ends to maintain its height in the field.

5. As far as nozzles are concerned, hollow cone nozzles are of little or no use on boom sprayers. The distribution depends too much on the boom height. It has still to be proved that solid cone nozzles can compete with good flat spray nozzles for boom spraying.

If we use the available knowledge I think we can make much better sprayboooms than the ones we are using today. Then it should also, in many cases, be possible to reduce the dose of chemicals, and still obtain satisfactory results. But who is responsible for the developments and when are we going to introduce the equipment for the growers?