5.
The Physics of Application

From p190

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RELATIONSHIPS OF HYDRAULIC NOZZLE AND SPINNING DISC SPRAY CHARACTERISTICS TO RETENTION AND DISTRIBUTION IN CEREALS

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ABSTRACT

A series of hydraulic pressure nozzles were examined for droplet spectrum and used to spray cereal plants at different stages of development under controlled conditions. The spray solution was aqueous surfactant containing sodium fluorescein. For comparison some plants were also sprayed with a spinning disc (CDA) atomiser. The quantity of spray deposited on different parts of the plants and on the soil were measured using fluorescence spectrometry after extraction. The results obtained were compared with deposit data obtained from field experiments in which similar atomisers were used to apply a fungicide/tracer mixture and the biological consequences of spraying were also assessed.

The results show a tendency towards greater retention, sometimes with reduced crop penetration, by reduced volume sprays containing smaller droplet sizes. While there is some correlation between deposits obtained indoors and in the field, and between doses deposited and biological effects, the relationships were rarely simple, presumably because other factors such as coverage of the plant surface might be limiting.

INTRODUCTION

The application of pesticides (including fungicides, insecticides, and p.g.r's) by conventional, high-volume techniques usually achieves the desired biological effect. It does this by depositing dilute chemical over a large proportion of the target surface. However, unless various other criteria are met, this or any other method of application cannot be said to be efficient. These criteria include (1) depositing a reasonable proportion of the applied chemical on the target, (2) keeping non-target contamination to a minimum, and (3) ensuring that the treatment is cost effective and timely.

The advent of laser techniques for measuring droplet spectra in flight (Knollenberg, 1970; Swithenbank et al. 1977) has shown the various ways in which a given volume of liquid may be atomised. Further, the ability to quantitively and qualitatively characterise the resultant deposit offers information about the retention of these sprays by plants.

In a typical fungicide application to cereals (winter barley GS 30-31) at 200 l/ha, using 110° flat fan nozzles (e.g. 11003 at c. 3 bar pressure), the following spectrum is usual. A volume median diameter (V.M.D) of c. 180 μm, 80% of the spray in droplets of 60-350 μm diameter with 20% of the droplets < 20 μm and 10% > 350 μm. Several possible sources of inefficiency are obvious. (1) Droplets < 100 μm diameter can drift and thus slightly reduce the dose deposited, and probably more importantly, increase non-target contamination. (2) Drops > 350 μm diameter are poorly retained on leaves (Hartley and Brunskill, 1958), reducing retention efficiency and increasing soil contamination (Scaefer and Allsop, 1983). Field evaluation of this type of application at Long Ashton in 1984 (Cooke et al. this symposium) showed that only c. 50% of applied chemical was retained by the target.

Hydraulic nozzles, whilst providing a cheap and convenient method of producing spray droplets, are difficult to modify in terms of width of droplet spectrum produced. Low pressure nozzles, for example reduce the driftable component of the spray but increase the large (> 350 μm) component. This may be advantageous in reducing drift but also reduces the portion of the spray which in some cases is more easily retained (Lake, 1977) and increases the chance of soil contamination.

We wished to examine the deposition obtained on cereals by using hydraulic nozzles in different ways: (1) applying the same volume per hectare in sprays of different droplet spectra; (2) comparison of large and reduced volume applications, again with various droplet spectra; (3) examination of the effect of varying pressure using a given nozzle; (4) the effect of reducing droplet velocity.

In order simultaneously to reduce both large and small droplet components and control overall droplet size, rotary atomisation (spinning discs, cups and to some extent cages) provides the best alternative to hydraulic nozzles. In this study a Micromax (Micron Sprayers Ltd.) was used to apply much reduced volumes with various defined droplet spectra.

Controlled droplet application (C.D.A.) techniques are becoming increasingly popular, not only because the droplet spectrum produced may avoid wastage and in some cases improve deposition, but because the reduction in spray volume provides other logistical advantages. For example, reducing application volumes for cereal herbicides from 200 l/ha to 40 l/ha can greatly decrease the time required for spraying and the degree of soil compaction. Furthermore, the greater work rates and virtual absence of herbicide containing driftable droplets allows spraying to be completed during optimal conditions, aiding improved timeliness of application. The technique may or may not allow reductions in chemical dose to be made; herbicide applications in cereals generally use the recommended dose, whilst work in top fruit has shown that insect pests may be controlled with much reduced volumes and doses (Cooke et al 1976). In top fruit some diseases, e.g. apple powdery mildew, are difficult to control with any fungicide dose in reduced spray volumes, possibly due to the generally smaller surface cover obtained (Herrington and Baines, 1983; Herrington et al this symposium)

Much effort is currently devoted to the examination of novel application techniques (e.g. Hislop, 1983; Hislop et al this symposium) but valid judgements of their relative effectiveness and efficiency will need more fundamental information about the conventional techniques we hope to replace. This paper presents a preliminary study of deposition from a range of hydraulic nozzles and a CDA device and the correlation of this to biological data obtained in the field.

METHODS AND MATERIALS

Drop spectra measurements

A Malvern Particle Sizer (Model 2200) was used to measure the quality of spray produced by a variety of hydraulic nozzles under specified conditions. The spray liquid was tap water containing 0.1% v/v of the non-ionic wetting agent Agral 90 (I.C.I. Plant Protection PLC). Nozzles were placed

10 cm from the laser so that the beam passed through the middle of the long axis of the fan. Such an arrangement allows an assessment of the mean total spectrum as described by Arnold (1983). Drop sizes produced by discs rotating at defined speeds were measured by catching droplets on magnesium oxide coated slides (May, 1950) and analysis of deposits with an Optomax image analyser using the quoted spread factor of 0.86.

Retention of Spray by Plants

Winter barley (cv. Sonja) seed was hand sown at approximately field rate and spacing (660 seeds/m^2 with rows 10 cm apart), in large bakery trays (72 x 41 cm). Plants were grown outdoors until they reached stages of development approximately equal to field growth stages GS 30-31 and c. 45 (Zadoks et al. 1974). This technique provided field-like plants in easily portable units.

Plants in trays were sprayed indoors in as reproducable a manner as possible. A small spray boom fitted with three hydraulic nozzles spaced at 50 cm for a spinning disc, was attached to a trolley carrying a gas cylinder to pressurise a liquid reservoir. The trolley was drawn along a track at 2 m/sec (7.2 kph) by an electric motor and pulley. The centre hydraulic nozzle or spinning disc was aligned over the centre of the long axis of the tray and the height of the nozzles over the plants adjusted as necessary (e.g. 40 cm for 110° nozzles and spinning discs and 60 cm for 80° nozzles). On each spray occasion, aluminium foil covered plates (50 cm^2) were placed on the ground at either end of the trays. Plants and foils were sprayed with the liquid used for the droplet spectrum measurements containing in addition sodium fluorescein (B.D.H. Chemicals) at 0.05% w/v for the hydraulic nozzles and 0.1% w/v for the CDA applications. Each application consisted of a single pass replicated three times.

Plants and soil were allowed to dry before sampling. Ten replicate plants were taken at random from near the centre of the two central rows of each tray, separated into plant parts as shown in Figure 1 and extracted with 10 ml of 0.1M phosphate buffer (pH 7.1) containing 0.05% Triton N101 wetting agent in glass vials. Foils were similarly extracted in 40 ml of buffer. Samples were left overnight in a dark cold room (4°C) before fluorescence was measured with a Perkin Elmer 2000 fluorescence spectrometer at excitation and emission wavelengths of 449 and 510 nm respectively. Measured fluorescence was quantified using fresh standard solutions in the extraction liquid on each occasion. The areas of the plant parts were measured using the Optomax image analyser and the quantity of spray retained per cm^2 calculated. Deposition on foil was measured similarly and used to calculate actual spray output.

Since it was impossible to make all comparisons at the same time, treatments were applied in small groups at approximately weekly intervals. To take account of variation in spraying and retentiveness of the plants with time, a standard treatment (200 l/ha using 11003 nozzles at 3 bar) was included in each group of treatments. Since it was found that deposition of the standard spray varied somewhat from time to time, it was necessary to transform the data from different application dates. Deposition data ($\mu g/cm^2$) were calculated as a percentage of the dose recovered from the aluminium foil. The relative retention index (i.e. trial spray (y) compared with standard spray (x),) and the variance of the ratio were calculated as follows:-

$$SE\ (x/y) \ = \ \frac{\sqrt{\bar{y}^2 * SE\ (x)^2 + \bar{x}^2 * SE\ (y)^2}}{\bar{y}^2}$$

where $\bar{x}$ (SE) is the mean and standard error of % recovery from the standard spray and $\bar{y}$ (SE) is the mean and standard error from the trial spray.

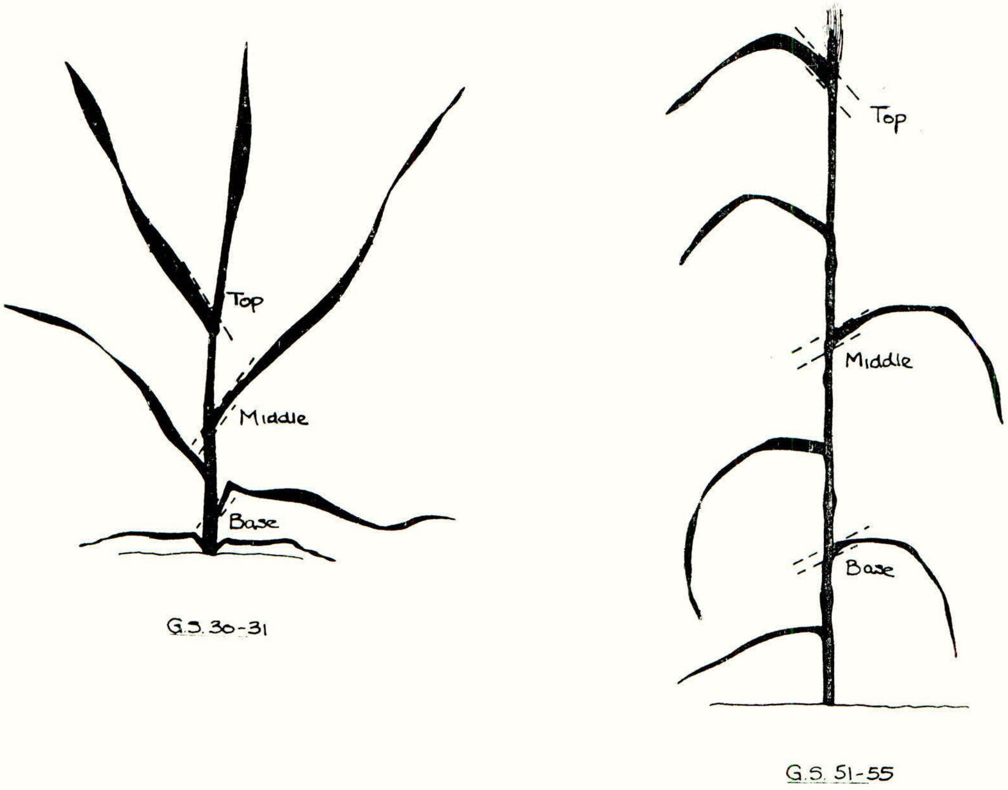


Fig. 1. Portions of winter barley plants (cv. Sonja) sampled at both growth stages.

RESULTS AND DISCUSSION

Table 1 shows the droplet spectra measured with the hydraulic nozzles and CDA atomiser used as specified. For a given nozzle size increasing pressure increased throughput but decreased volume median diameter (VMD) and increased the proportion of the spray in the small droplet size, while changing from a standard pressure nozzle to a low pressure type had the opposite effect. Changing from a hydraulic nozzle to a spinning disc dramatically reduced the width of the droplet spectrum, as shown from the R values (VMD/NMD ratio).

TABLE 1

Operating parameters for different atomisers and the resultant droplet spectra and application rates.

Atomiser	Pressure (Bar)	l/ha (*)	V(10)	VMD	V(90)	NMD	VMD/NMD (R)	% Volume < 100	% Volume > 350 (μm)
110015LP	1	100	114.9	290.7	525.2	54.9	5.3	7.6	36.4
110015	3	100	46.0	141.2	288.5	14.9	9.5	32.2	4.1
8003	3	200	87.2	228.1	420.9	39.0	5.9	12.9	20.1
11003	2	163	75.9	208.1	395.4	30.9	6.7	16.1	16.0
11003	3	200	63.6	181.0	352.7	23.9	7.6	21.2	10.3
11003	4	231	54.9	168.5	344.3	17.8	9.5	25.1	9.4
MICROMAX (3500 rpm)		40	100.2	180.6	262.8	90.8	2.0	9.9	0.3
MICROMAX (3500 rpm)		12.5	79.3	142.3	206.6	72.2	2.0	19.6	0.0
MICROMAX (5000 rpm)		12.5	50.0	92.7	137.4	43.2	2.1	58.3	0.0

* at 50 cm spacing for hydraulic nozzles and a forward speed of 7.2 kph. Hydraulic nozzle spectra measured using Malvern Particle Sizer Micromax droplets captured on MgO slides and measured using Optomax image analyser.

V(10) Drop diameter below which 10% of the volume lies.

V(90) Drop diameter below which 90% of the volume lies.

The effects of applying the different sprays is summarised in Table 1 and the resultant deposits on whole young plants (<u>c</u>. GS 30) is illustrated in Figure 2, while the distribution of spray on young plant components is recorded in Figure 3. Similarly, the retention on older whole plants and plant parts are shown in Figure 4 and Figure 5 respectively. Spray quality considerably affected retention and distribution. For example, the low throughput 110015 nozzle at 3 bar pressure deposited spray more effectively than other atomisers when used to spray young plants. Increased droplet size resulted in relatively reduced spray retention (comparing 8003 nozzle with standard 11003). However, this was not totally consistent because when the 11003 nozzle was used at 2 bar and 4 bar pressure to spray young plants, the change in droplet spectrum (VMD of 208 and 169 μm respectively) did not alter relative retention. This could perhaps be due to the fact that increasing pressure increased throughput (from 163 to 231 l/ha) and altered droplet velocity. Further, when the CDA atomiser was used to apply small volumes (12.5 l/ha) in small droplets, retention efficiency was relatively poor (Figs. 2 and 4), contrasting with the general observation that small droplets produced by hydraulic nozzles are captured relatively well.

Fig. 2. Retention of spray, relative to 11003 at 3 bar pressure by whole plants at GS 30-31 shown as mean ± 95% confidence limits. (Numbers above are coefficients of variation)

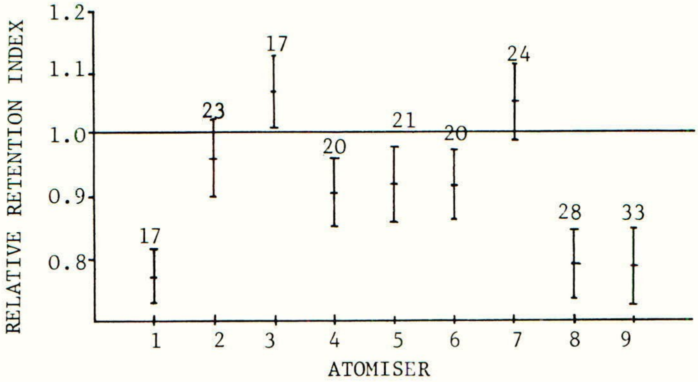
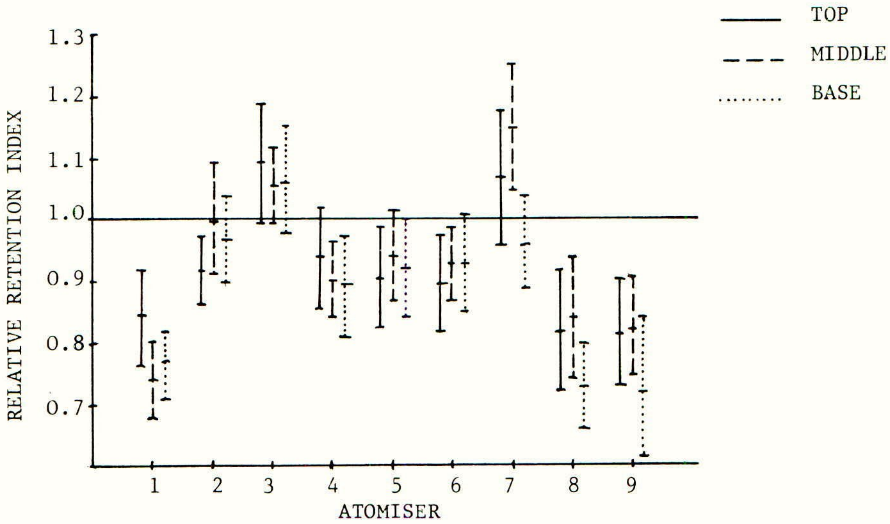


Fig. 3. Retention of spray relative to 11003 at 3 bar pressure by portions of plants at GS 30-31 shown as mean ± 95% confidence limits.



1 - 8003
2 - 11003 @ 60 cm
3 - 110015
4 - 110015 LP
5 - 11003 @ 2 bar
6 - 11003 @ 4 bar
7 - CDA 40 (VMD 180 μm)
8 - CDA 12.5 (VMD 90 μm)
9 - CDA 12.5 (VMD 140 μm)

Fig. 4. Retention of spray, relative to 11003 at 3 bar pressure by whole plants at GS 51-55 shown as mean ± 95% confidence limits. (Numbers above are coefficients of variation)

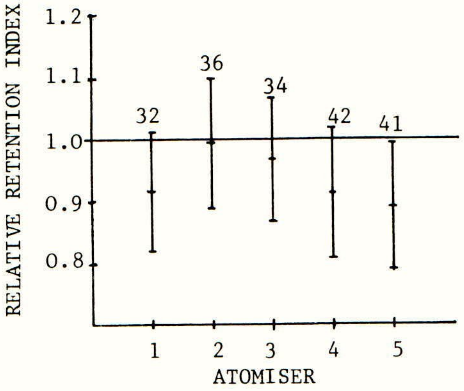
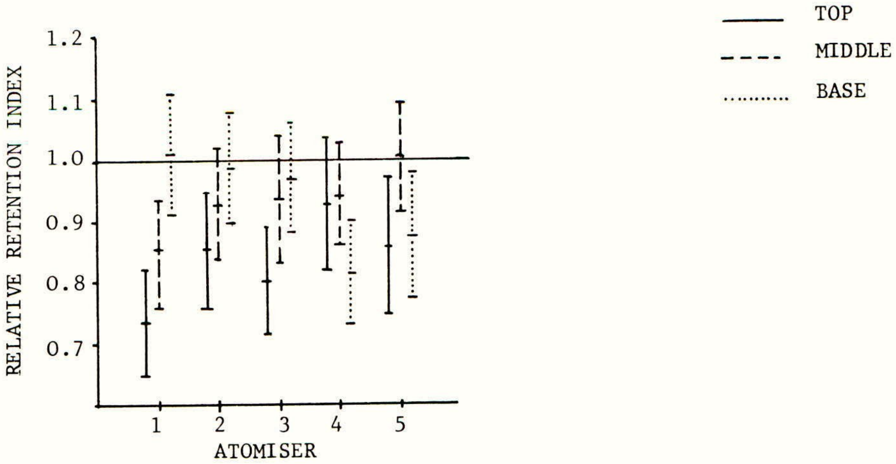


Fig. 5. Retention of spray, relative to 11003 at 3 bar pressure by portions of plants at GS 51-55 shown as mean ± 95% confidence limits.



1 - 8003
2 - 110015
3 - 110015 LP
4 - CDA 40 (VMD 180 μm)
5 - CDA 12.5 (VMD 90 μm)

Examination of Figures 3 and 5 also indicates some interesting and potentially important aspects of spray distribution throughout the crop. For example, while the large droplet 8003 nozzle deposited relatively poorly on the base of young plants, penetration into taller crops was relatively good. It is also clear that under the conditions described, the CDA sprays penetrated the crops rather poorly at both growth stages.

Hydraulic nozzles impart a downward velocity to spray droplets and it was thought that raising the height of a nozzle above the crop (from 40 cm for the standard application to 60 cm for nozzle 2 in Fig. 3) might decrease penetration, but this was not so. Drops produced from spinning discs only have vertical velocity due to gravity and this might account for some of the observed poor penetration for the smaller drops examined: large droplets (180 μm) penetrated young plants well but were less effective in penetrating larger plants.

The 8003 nozzle produced the lowest coefficient of variation for total deposits while the CDA sprays had the highest variation (Figs. 2 and 4). It is suggested elsewhere in these proceedings (Cooke _et al_) that this degree of variation is an important factor affecting the efficacy of pesticide delivery systems in the field. Also, total capture of spray from a 110015 nozzle was greater than that from the standard (11003) nozzle. These similarities suggest that although the experiments described were done under controlled conditions, they do reflect field observations. However, the significance of total capture, distribution of spray and variation relative to biological efficacy is a complex topic (Hislop, 1985) and too much emphasis should not be placed on the present results. The quality of deposits on plant surfaces is often an overriding consideration (Herrington _et al_ this symposium). Our present observation that CDA at 12.5 l/ha and 140 μm drops compared with 90 μm drops produces more variable deposits at the base of young plants (Fig. 3) may be important in this respect. Clearly more work of this nature is needed - preferably using pesticides rather than ideal solutions. However, we suggest that this type of work will serve to widen the data base for the rather poorly understood topic of pesticide spraying. Most of the experiments done to date are largely _ad hoc_ and defy logical interpretation (Hislop, 1983).

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THE EFFECT OF VOLUME OF APPLICATION FROM HYDRAULIC NOZZLES ON THE PARTITIONING OF A PESTICIDE SPRAY IN A CEREAL CANOPY

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ABSTRACT

A comprehensive field trial was made by ICAP and Ciba-Geigy UK to investigate the fate of droplets sprayed from hydraulic nozzles in a series of cereal canopies. By using fluorimetric tracing techniques it was possible to account for the fate of the spray at both different canopy levels and at the ground.

Three application volumes (50, 100 and 200 l/ha) were applied to 3 different cereal canopies; growth stages 32 (barley), 37 (barley) and 39 (wheat).

Results showed that in the three different crop conditions the low volume rates performed as well as the higher volumes in terms of volume of deposit reaching the canopy. Other factors such as droplet number per hectare and variations of deposit also compare favourably with the high volume application, suggesting that the logistical advantages of applying at low volume rates can be achieved with low volume hydraulic nozzles without loss of effect.

It is hoped that the information from this work will augment the information presently available on exactly what happens to agricultural sprays.

INTRODUCTION

Despite many recent innovations in application equipment, many farmers in the UK still use the standard boom and hydraulic nozzle, either because the cost of re-equipping with the latest technology has so far been prohibitive, or because of a reluctance to move away from a familiar and reliable technique.

Since so little comprehensive and valid scientific data is available (Hislop, 1983) which is able to clearly compare present hydraulic nozzles with the new techniques of atomisation, it is easy to understand the reluctance of the farmer to invest extra money in a largely unproven and confusing market.

The following work has been taken from extensive field trials undertaken by Ciba-Geigy and ICAP to investigate the fate of spray in the cereal canopy. Because of the many people still using hydraulic nozzles, it is important that the use of agrochemicals through these sprayers is made as efficient as possible. For this reason a range of conditions have been chosen to represent different cereal canopies, as well as a range of application volumes, in order to investigate the possibility of using low volumes from conventional systems, thus obtaining some of the logistical advantages achievable with low volume CDA application.

By examining different crop growth stages it has been possible to highlight the conditions under which most chemical has been wasted and where improvements will be most easy, or most difficult, to obtain.

The increased pressure from environmental protection agencies highlights the growing need for awareness of exactly where the chemical applied finally lands. This makes the deposit reaching the ground, as well as the driftable fraction, an important parameter for assessment.

The performance of the application is measured by volume of spray deposited at various target levels in the canopy. This method does not allow the estimation of droplet size or number on the target. However, the droplet spectrum has been measured using a Particle Measuring System laser probe for each nozzle which will indicate typical droplet sizes and numbers present in each situation.

MATERIALS AND METHODS

Crop details

In order to test each spray parameter in a range of crop conditions three different sites were chosen. These sites gave three different growth stages and had different canopy structures with both different degrees of ground coverage and different extents of canopy depth.

TABLE 1

Crop conditions

Site	Crop Type	Growth Stage	Density Stems/m^2	LAl	Mean Wind Speed m/sec
1	Barley	2nd Node (32)	650	2.7	1.8
2	Barley	Flag Leaf (37)	780	4.3	3.3
3	Wheat	Flag Leaf ligule visible (39)	590	6.5	1.7

Sites 1 and 2 were typical growth stages for spring chemical applications e.g. broad leaved weed control. Site 3 was typical of later UK summer applications e.g. fungicide or insecticide applications.

Each treatment was replicated three times in a completely randomised design using 6 x 30m plots. Application was made using a full sized self-propelled boom and nozzle sprayer using flat fan nozzles at 0.5m spacings. The nozzles used were Spraying Systems brass 8001, 8002 and 8004 operated at 275 kPa. At a sprayer forward speed of 2.2 m/sec this gave a range of application volumes of 50, 100 and 200 l/ha respectively.

Tracer

The spray solutions consisted of a commercial fungicide, TILT TURBO (1 l/ha), and the fluorescent tracer HELIOS OB formulated as an emulsifiable concentrate to yield a nominal tracer dose rate of 5 g/ha. In order to be able to compare different treatments accurately, the small difference in dose of tracer applied for each treatment must be accounted for. This is calculated from tank samples and the volume of spray applied.

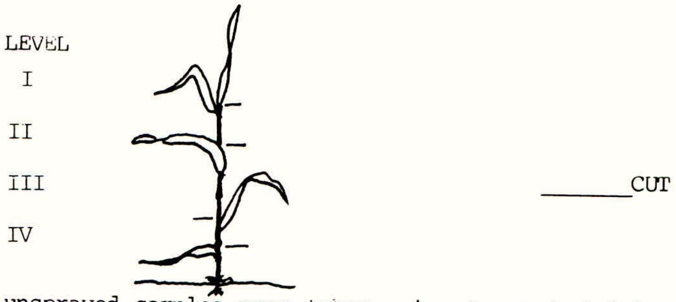
This tracer is comparatively light stable but it is still important that plant samples be removed to the dark within 30 - 40 minutes of spraying to minimise the effect of photodegradation. The tracer is not strongly absorbed into the surface of the plant but the spray was washed from the sectioned stems within 24 hrs using carbon tetrachloride to ensure maximum recovery from the leaf.

Sampling procedure

Since it is known that many chemicals give their best biological result if applied at a particular canopy level, it is important that deposit is not measured as total canopy deposit, but as a deposit at the various heights in the canopy. This allows the assessment of the suitability of each technique for applying chemical to a desired target level.

Single plant stems were cut into 3 or 4 sections in accordance with figure 1. Sections from the same level on 20 to 25 stems, depending on stage of growth, were bulked to form a section sample. Two such section samples were taken from each plot giving a total of 6 section samples per treatment when replicates are included.

Fig. 1 Sections of stem taken for sampling



Blank unsprayed samples were taken prior to each trial to ensure no background level of fluorescence existed.

Ground deposits were measured using 30 x 50 mm acetate sheets placed beside the base of the plant stem.

The combination of foliage area in each sample (cm^2) and absolute deposit (ng), could be used to calculate deposit density values. However, it is not normally possible to directly measure each section sample area, but an estimate of each section area can be made from its fresh weight by applying an area per weight factor calculated from unsprayed samples (cm^2/g). Total area in a section sample was composed of the silhouette area for the leaf and a cylindrical surface area, using a mean stem diameter, for the stem fraction of the section sample.

RESULTS

The results have been illustrated using a Deposit per Unit Emission (D.U.E.) which expresses deposit density (ng/cm^2) as a proportion of the total chemical which was applied (g/ha).

If reducing the volume of application through hydraulic nozzles is to be adopted, then it must give as good a biological effect as present standard applications. Fig 2a shows how, for a small canopy which incompletely covered the ground, the deposit densities were very similar. It is most unlikely that by using standard chemical manufacturers dose rates that any biological difference would be seen for this degree of difference. It is, however, interesting to note that already the 50 l/ha nozzles have demonstrated trends towards improved deposit in the upper canopy, with a reduced amount of chemical which reached the ground. Middle and lower canopy deposits (Level II and III in Fig 2a) showed very little difference in treatments. This result is not surprising when the droplet sizes of Table 2 are considered. The high volume nozzle (8004) produced many more large droplets of sufficient kinetic energy to rebound from the leaf surface. In a crop with such an open canopy structure there is a high probability that those droplets which are reflected by the upper levels, will not be re-intercepted by the lower levels. This means that especially in the high volume application, not only will ground deposit have arisen from direct impact of spray but, the ground will also have received reflected droplets which struck the upper canopy leaves.

Because of the exposure of each leaf level through the lack of higher canopy cover, the actual deposit of spray recorded per unit area of leaf was higher than for canopies of a larger leaf area index (LAI), especially for the lower canopy levels.

On Site 2 the canopy consisted of a much taller structure with overlapping and shadowing of lower levels by the upper canopy vegetation. The LAI had increased from 2.7 to 4.3 and the deposit densities had fallen commensurately; clearly as leaf area increases for a given dose rate then the deposit must either be spread more thinly or must not reach some of the leaf canopy. This would be especially true once the ground had been fully covered by the canopy. As with Site 1, the overall deposit pattern remained similar for 50 and 100 l/ha compared with the standard 200 l/ha (see fig 2b.). Also, as in the previous site, the lower volume applications recorded a higher mean deposit in the upper region of the plant (the newly emerged flag leaf in this example).

It was not until Site 3 (wheat) that real difference began to show (see fig 2c.). The 50 l/ha upper canopy deposit had a significantly higher deposit density (P = 0.05) than that for 200 l/ha. With an average canopy height in excess of 1m there was a clear gradient in deposit density from upper to lower canopy levels. The lower canopy deposit densities were much less than previous sites because of the influence of shading from upper canopy levels which reduced the total amount of spray available for interception.

Ground deposits were reduced as the amount of ground covered by leaf area increased until, at the site 3 with a LAI of 6.5, the ground deposit represented only between 4 and 10 per cent of the total measured spray deposits (Bryant et al. 1984).

TABLE 2

Drop Spectra Measurement

Nozzle	Pressure kPa	VMD (microns)	NMD	Per cent Vol<100 microns	Drops per litre x 10^{-9}	Drops/ha x 10^{-9}
8004	275	315	44	2.8	0.56	111.0
8002	275	247	38	4.5	0.95	94.9
8001	275	220	43	5.7	1.09	47.1
8001LP	150	255	37	3.3	0.78	39.0
8002LP	150	315	40	2.0	0.47	47.0

DISCUSSION

Whilst the thrust for improving chemical application must be maintained, it is becoming apparent that improvements from new equipment are often only found in isolated situations.

Present day CDA techniques have so far been unsuccessful at demonstrating reliable and widespread increases in deposit on a plant over those techniques in standard practice. Elliott (1980) found that "as far as herbicides are concerned, there has been little scope for reducing chemical dose" using CDA applications. In similar comparisons using the fungicide tridemorph in barley, Evans (1979) found that CDA applications "would give almost as good a result as spraying at higher volumes using hydraulic nozzles". Indeed, the example of site 3 demonstrates how difficult it will be to improve deposit densities since upwards of 90% of the spray is already being caught by the crop canopy (Bryant et al 1984).

With such results as these, the evidence for changing to the present CDA techniques comes from few isolated cases of improved deposit and even fewer cases of improved biological effect.

Evans (1979) states that workrates could be increased by as much as 25% when spraying fungicides at reduced volumes (50-55 l/ha from 200-280 l/ha) through hydraulic nozzles. Increasing workrates will not only provide greater flexibility with days available for spraying but will also allow earlier applications to be made; prompt applications to both disease, weed and pest complexs in the early stages of development often give better biological results.

Clearly there are other factors to be considered before a farmer should reduce his application volume to 50 or 100 l/ha, such as the increased risk from spray drift.

Table 2 shows the volume of the total spray which is present as droplets of less than 100 µm diameter. It is this drop size fraction which is thought to be most at risk from drifting from the target site and which is seen to increase from 2.8% for the 200 l/ha nozzle to 5.7% for the 50 l/ha nozzle. So, on the one hand a farmer is able to increase his work rate and hence widen his spray window, particularly an advantage when adverse weather conditions exist during a disease upsurge. However, the number of days available which provide a low enough windspeed to avoid extra drift from the use of low volume nozzles will, conversely, tend to reduce his spray window.

One possible method of ameliorating this problem is to adopt a low pressure spraying system. The choice of nozzles which can be used for low volume spraying is wide; the examples shown here relate to a tractor forward speed of 2.2 m/sec. By using a low pressure (LP) nozzle an equal through-put of liquid can be obtained by working at a reduced pressure. These nozzles tend to reduce the driftable fraction of small droplets (% vol <100 µm in Table 2) but do also produce an increase in the number of large droplets, because of their larger orifice size, with a consequent reduction in total number of droplets per litre of spray. Whether the increase in overall droplet size would negate the advantages of reduced bounce, originally thought to be the major reason for improved deposit, is an area requiring further investigation. Also, the affect that the reduced droplet numbers would have on biological result is unclear and confounded by the complex interactions of type of chemical used, crop and weed structure.

The LP nozzle does however have the advantage that its larger orifice size is less susceptible to blockage, a complaint often leveled against the use of low volume hydraulic nozzles.

Given the undoubted ability of the spinning disc to produce the type of droplet spectrum which favours both biological effect (dropsize, drop number, and good retention), and which can be operated so as to reduce the driftable fraction and oversize drop fraction, what is the major problem with CDA equipment at present?

The biggest hurdle to its success when compared to low volume hydraulic nozzle is thought to be the unreliability of results through a large coefficient of variation of the spray pattern. This was demonstrated by Robinson (1984), using data from the same field trial as presented here. He showed that the horizontal spinning disc gave larger coefficients of variation than hydraulic nozzles, especially in the lower canopy region or where the canopy was dense. This may be caused by the following:

Firstly the difficulty in combining the single spray pattern on to a multiple unit boom to give a good spray distribution.

Secondly the susceptibility to wind of the spray cloud which is often released horizontally and which then sediments to the crop canopy at terminal velocity. This leaves the droplet cloud vulnerable to random movement from the turblent air above the canopy; the vertical spinning disc may help improve this problem.

Finally, these atomisers show an increased susceptibility to boom movement, both in magnitude due to their extra weight and, in some designs, in a variation of flowrate shown with vertical boom displacement.

The hydraulic nozzle is, however, better able to match the individual spray distribution to form an even distribution across the boom. It also has the advantage that droplets are both projected at a velocity above their terminal velocity (Lake 1977) and are also carried within an entrained air stream towards the canopy making them less susceptible to turbulent air perturbations.

CONCLUSIONS

The recovery and partition of spray on the canopies were the same at 50, 100 and 200 l/ha except on site 3 on the flag leaf where the 50 l/ha treatment gave a D.U.E. of 1.8 compared with 1.1 and 0.9 with the larger volumes. Deposits on other sections of the crop were equivalent for the three volume application rates.

A major effect was due to the canopy leaf area index increasing from 2.7 to 6.5 which caused the recovery of spray on the canopy to rise from 65% to more than 90%, with a corresponding decrease in the fraction reaching the ground below.

Although these trials did not measure the proportion of spray which drifted from the site directly, it is believed that very little loss in deposit was experienced due to drift. The volumes in the driftable fraction were in the range of 2.8% to 5.7% and even if all of such small drops were to be lost through drift, the precision of the D.U.E. measurements would not be high enough to detect a decrease in recovery this slight.

It is probable that the 50 l/ha treatment applied with hydraulic nozzles provides most of the logistic advantages of the low volume of spray which can be applied using spinning disc atomisers (CDA) but unlike CDA, it is able to give the same physical distribution of spray as 200 l/ha applied with nozzles. Except for treatments applied to the flag leaf, when 50 l/ha may be better than 200 l/ha, and for weeds below the canopy early in the season when 200 l/ha gave an increase in D.U.E. of 1.2 at ground level, the range of spray volumes are, from these data, expected to result in equal biological performance.

The disadvantage of using reduced volumes through hydraulic nozzles are mainly the increased proportion of droplets at risk from drift and the reduced total number of droplets per hectare produced per litre of spray compared to conventional 200 l/ha applications. Careful choice of volume rate with chemical formulation may also be required to avoid nozzle blockage.

In conclusion, it is thought that the hydraulic nozzle still has both scope for improved use and provides good all round performance when used under a wide range of conditions. By knowing clearly how it performs, the system can be adapted more closely to the needs of the current spraying situation.

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Fig. 2a. SITE 1 Barley

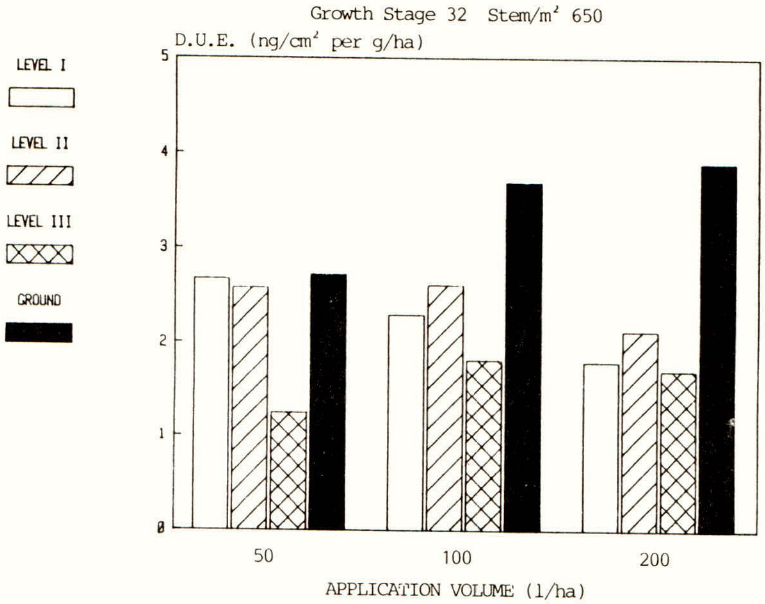
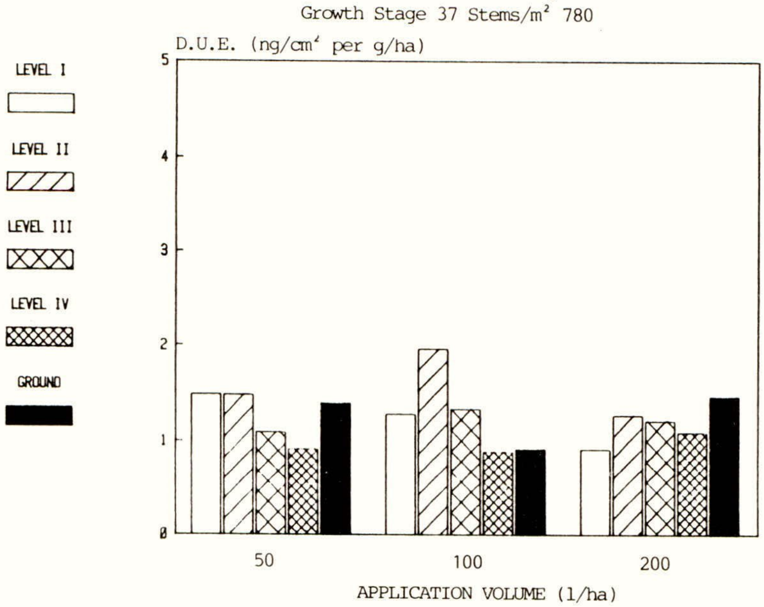


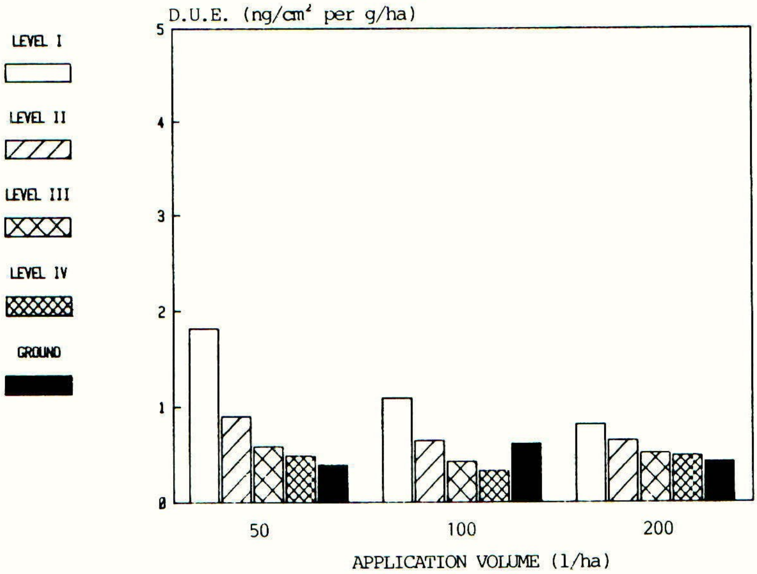
Fig. 2b. SITE 2 Barley



Figs. 2a-c show the deposit density in ng/cm² per g/ha of tracer applied to the plot. Each legend refers to the level in the canopy at which the deposit was measured.

Fig. 2c. SITE 3 Wheat

Growth Stage 39 Stems/m² 590



AN EVALUATION OF AERIALLY APPLIED ULV AND LV SPRAYS USING A DOUBLE SPRAY SYSTEM AND TWO TRACERS

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ABSTRACT

A simultaneous comparison of aerially applied low volume (20 l/ha) (LV) and ultra low volume (1 l/ha) (ULV) sprays was made in a barley canopy (var. Igri) using a single aircraft fitted with a twin spray system and two tracers. This system reduced the spray work and eliminated the variability normally associated with plot differences and changing meteorological conditions. Three trials were performed. Spray deposits were assessed on the crop at different levels in the canopy and on artificial collectors at canopy height and the ground. Down wind drift was assessed using artificial collectors at canopy height and on masts. A colorimetric method was used for analysing the spray deposits. In all three trials the total deposit on the crop was greater for the LV than for the ULV sprays. A spray mass-balance was attempted for one trial. This indicated that a greater amount of ULV spray was off-target than the LV spray. The twin-spray system provided a more reliable comparison of application techniques than previously reported methods.

INTRODUCTION

Much work has been carried out over the years on comparing the effectiveness of different aerial application techniques (Burgoyne et al. (1973), Yates and Akesson (1975) and Grumbles et al.(1980)), but ideal experimental conditions have rarely been achieved. Two major problems that have to be faced in all aerial trial work are the often excessive variance between plots, resulting from their necessarily large size, and vagaries in the weather at the time of application. These problems cannot be easily resolved, for example Southwick et al. (1983) when comparing applications on cotton, had to resort to using different plots on different days with different aircraft. Courshee (1978) attempted to minimise the problems by the simultaneous application of two tracers to the same plot using two aircraft, but even this technique is not wholly satisfactory since one aircraft cannot fly closely through the wake of another and short term meteorological fluctuations can still be present.

Clearly, there is a necessity for the truly simultaneous application of two tracers to the same plot. For this reason a twin spraying system was developed (Wyatt, 1978).

The objective of the experiments reported here was to utilise the twin-spray system to evaluate the deposition and movement of spray from Low Volume (L.V.) (20 l/ha) and Ultra Low Volume (U.L.V.) (1 l/ha) sprays applied to cereal crops.

MATERIALS AND METHODS

Application Techniques and Equipment

The aircraft for the experiments was I.C.A.P.'s Auster J5L Aiglet, a high wing light monoplane with a 10m wing span. The aircraft was equipped with a twin tank spraying system and two separate external spray systems. The twin tank system consists of two 22 litre stainless steel tanks that can be pressurised independently by a small centrally mounted high pressure air cylinder. Each system is actuated by solenoid valves and the whole assembly can be positioned in the rear passenger compartment of the Auster aircraft. A more complete description of the system was given by Thomas (1984).

For the L.V. application a set of booms equipped with hydraulic nozzles were installed. One boom was positioned under each wing of the aircraft with a small boom positioned under the fuselage. Although the under wing booms spanned the full width of both wings, nozzles were not fitted within 0.75 metres of the wing tip to prevent excessive drift. This is common practice to prevent undue losses from droplets being entrained in the wing tip vortices (Parkin and Spillman, 1980). The booms were equipped with 38 hydraulic nozzles orientated at 90° to the direction of the aircraft flight and fitted with Spraying Systems 8005 flat fan spray tips. The nozzles were operated at 1.7 l/min/nozzle of water using 400 kPa to produce the desired application rate of 20 l/ha.

For ULV application two Micronair AU3000 atomisers were mounted on special brackets under each wing at the mid span position. The atomisers were set with a 25° blade angle so as to produce 8,000 r.p.m. rotational speed at the 80 m.p.h. air speed used in the experiments. The liquid used to simulate a U.L.V. formulation was the glycol ether butyl-dioxytol. This was discharged at 1.6 l/min/atomiser for the desired 1 l/ha application rate.

Prior to the experiments on cereals, the aircraft systems were calibrated by spray runs over artificial collectors at Cranfield airfield. Using the analysis methods developed by Parkin and Wyatt (1982) it was estimated that the likely coefficients of variation for swath widths of 15m were 13% for the L.V. application and 64% for the U.L.V. These values were considered as being typical of practical applications and this swath width was chosen for the field application. A flying height of 3 metres was used in all the trials.

Assessment Methods

The tracer system chosen consisted of 2 inexpensive and innocuous food dyes, a red dye, Erythrosine, and a blue dye, Water Blue. The Erythrosine was used at 0.25% w/v in water for the L.V. spray and the water blue at 0.5% w/v in butyl dioxytol for the U.L.V. spray. The dyes were detected using a Bausch and Lomb spectronic 20 colorimeter fitted with a flow through cell to speed analysis. It was established that each dye caused some interference at the peak detection wavelength of the other, but this presented no problems since allowance could be made using the procedure outlined in the Appendix.

This procedure was found to be somewhat simpler than that outlined by Johnstone (1977), and was originally developed by the primary author for tracing several simultaneous applications.

The target crop, barley, was found to retain a proportion of the dyes. The recovery coefficients were found to be 80% for Water Blue and 51% for Erythrosine. Similar values to these were obtained in a preliminary unpublished experiment with oil seed rape.

Experimental Procedure

Comparisons between the application systems were made on 3 occasions in 1984 on the same field of barley (variety Igri) at Wharley Farm, Cranfield. The dyes were found to fade in sunlight sufficiently to allow this. The field was marked for six 100m long spray runs at 15m spacing.

The field was sprayed in 'racetrack' fashion (i.e. one direction only), and only on occasions when there was a true crosswind so that portable masts could be used to assess the volume of spray moving out of the field. To improve detectability on the masts the applications were repeated. Acetate sheet collectors were mounted on 1.9cm diameter cylinders at 1m intervals up the 11m high portable masts. The masts were positioned at 25m and 75m downwind of the last swath.

In an attempt to assess the amount of spray entering the crop, 8 x 9cm acetate sheets were mounted on 10 x 10 cm aluminium tables at crop height. These were positioned at 2m intervals across the two centre swaths of the area to be sprayed. Similar collectors were placed on the ground to assess ground level deposition. Spray deposits on the crop was assessed by sampling 10 leaves at adjacent sampling positions. Samples were taken at 3 or 4 levels dependent on crop development. To assess off-target deposition further artificial collectors were placed at crop height and at 2m intervals between the last swath and the mast 75m downwind.

After sampling, both leaf and acetate collectors were washed with 10 ml aliquots of distilled water and the resultant solution measured for absorbance at 525nm and 630nm wavelength. Using a microcomputer program, the procedure as outlined in the Appendix was carried out to assess the volume deposited on the surfaces by each method of application. Samples were analysed within 2 hours to ensure minimal fading of dyes. Spray tank samples were taken for calibration before and after each application.

Planting densities, growth stages and leaf area indices were established so that deposits could be assessed as deposit per unit area sprayed/emission per unit area or D.U.E. (Courshee, 1960). Leaf areas were assessed by means of weight-area correlation (Last 1984). During all the spray experiments wind speeds were measured at canopy level and 11m above ground level.

Experimental Details

Experiments were carried out at growth stages 32, 53 and 55 during May and June 1984. The first trial was carried out in light winds but the second and third were carried out under moderate winds. (Table 1). Detectable off-target deposits were obtained on the collectors at crop height in all three trials. However, in the first two trials the amount of spray collected on the masts was insufficient to allow a spray accountancy procedure to be carried out. In the third trial a full spray mass balance was attempted. The plant deposition was estimated using the D.U.E. and making allowance for stem density and leaf area index. The amount of material deposited on the masts was estimated by considering what fraction of the spray released over the field passes the planes represented by each mast.

RESULTS AND DISCUSSION

The spray deposits at different heights within the crop are shown in Table 2.

The results of the spray mass balance are shown in diagramatic form in Fig. 1. Deposition on the horizontal artificial collectors and leaf surfaces is shown as the 90% confidence range. Confidence intervals were not established for the deposits on the masts since only one mast was used at each position.

At growth stage 32 a large proportion of the spray is deposited on the ground by the L.V. application as can be seen in Table 2. This is much reduced in the U.L.V. spray but there also appears to be significant reduction in volume deposited on the plant. At growth stages 53 and 55 the ground deposition by the L.V. application was less, presumably because of the larger surface area presented to the spray by the crop. At all growth stages the U.L.V. spray gave lower deposits on the plant than L.V. The deposition profile throughout the experiments was similar for both application methods with the top of the crop receiving the highest D.U.E.

It should be noted that the analysis employed here considers only deposited spray volume and cannot directly infer changes in biological efficacy. This is especially so for insecticides and fungicides where deposition in smaller droplets, such as from the U.L.V. spray, can be more effective than in larger droplets (Munthali, 1984). For this reason one should guard against concluding from these results that, because of the lower volume deposited on the crop, U.L.V. is inferior to L.V. for the spraying of cereals. What can be concluded is that the U.L.V. results show that a slightly lower proportion of the spray is deposited on the crop and a much reduced volume deposited on the ground below the crop.

The procedure adopted here for spray accountancy is different from that usually adopted (Lawson and Uk 1979) where a single swath is sprayed, but is considered to be more realistic. What is estimated here is the spray remaining airborne from area application. Spray remaining airborne at 25 metres downwind can be regarded as "over the fence" drift, spray deposited off target can be regarded as deposited in the next field, and (spray airborne after 75 metres) as long distance drift.

The amount of U.L.V. spray moving into the target field, as assessed by the horizontal collectors placed at canopy level, appears to be unrealistically low. This is undoubtedly due to the poor collection efficiency of horizontal surfaces to fine spray (Gregory and Stedman 1953). It is estimated that the correct figure is 50 - 70%. Collection efficiency problems also afflict the value for the spray deposited off target. It is considered that a matrix of narrow horizontal cylinders, say wires, could perhaps have provided a more realistic alternative. The assessments of the L.V. spray, and with the two aforementioned reservations, the U.L.V. are considered as reasonable. The results clearly show more spray remains airborne above the crop at 25m and 75m downwind with the U.L.V. spray. It also appears that increased off target deposition is also likely with the U.L.V. spray.

CONCLUSIONS

When spraying a cereal crop at application rates of either 20 l/ha L.V. or 1 l/ha U.L.V.:-

(i) Large volumes of the spray are deposited below the crop with the L.V. application.

(ii) The amount of material deposited below the canopy with both applications is reduced as the crop develops.

(iii) The volume of spray deposited on the barley crop is lower with the U.L.V. application.

(iv) The proportion of spray airborne at the field's edge, deposited in the next field and remaining airborne for long distances is greater with the U.L.V. spray.

Further work comparing 20 l/ha with a larger volume and droplet size, say 50 l/ha, would be of interest especially for applications to smaller fields common in Western Europe.

ACKNOWLEDGEMENTS

Much of the work reported here was carried out with the technical cooperation of Mr. J C Wyatt. The authors would like to thank Mr A.M. McVitie for his flying skills and Mr Howe for the use of his barley field.

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APPENDIX

Multicomponent Colorimetric Spray Deposit Assessment

The absorbance of monochromatic light by a solution of dye is a function of the concentration of dye c, its absorbitivity e, and the path length of light through the liquid b. The following law describes the relationship.

$$a = -\log t = e.b.c. \qquad \ldots(1)$$

where a is the absorbance and t the transmission of light. If a solution of dye is sprayed onto a surface of area $s(cm^2)$ then the deposit per unit area of q (ml/cm^2) can be established without recourse of knowing the absolute volume of dye concentration in the spray tank solution. This can be achieved by obtaining a calibration from a serial dilution of the tank solution and establishing a relative absorbance coefficient k, usually by regression, using:

$$k = \frac{a}{d} \text{ or } - \frac{\log T}{d} \qquad \ldots(2)$$

where d is ml spray tank solution/ml of dilution. The path length b need not be considered if only one colorimeter is to be used.

The deposit per unit area q can be calculated after the dye is removed by aliquot volume w (ml) by

$$c = \frac{a}{k} \text{ and } q = \frac{c.w}{s} \qquad \ldots(3)$$

Should an incomplete recovery from the target surface be achieved then this can be accounted for by

$$q = \frac{c.w}{s.r} \qquad \ldots(4)$$

where r is the fraction of dye recovered by the target surface as assessed by calibration.

The above equations assume only a single absorbant material per sample. With the simultaneous application of two or more dyes the situation becomes more complex. Considering, as an example, a two dye system, then the effect of the dyes on light absorbance is additive for any one wavelength. Hence at a wavelength denoted by (1) the absorbance a(1) is evaluated by

$$k(1,1).c(1) + k(1,2).c(2) = a(1) \qquad \ldots(5)$$

where k(1,1) is the absorbance coefficient for wavelength (1) of dye (1) and k(1,2) is the coefficient for wavelength (1) of dye (2). At another wavelength (2) then similarly

$$K(2,1).c(1) + k(2,2).c(2) = a(2) \qquad \ldots(6)$$

The above simultaneous equations can be solved by c(1) and c(2) if a(1) and a(2) are measured and the coefficients k(1,1), k(1,2), k(2,1) and k(2,2) are established by calibration at the wavelengths (1) and (2). Wavelengths are usually chosen as being the two peak absorbance wavelengths for the tracers and so k(1,1) and k(2,2) are the coefficients at the dyes' 'own' wavelenths; k(1,2) and k(2,1) are the interference coefficients. If more than 2 dyes are used then it can be shown that

$$\begin{aligned} k(1,1).c(1) + k(1,2).c(2) \; \ldots . k(1,n).c(n) &= a(1) \\ k(2,1).c(1) + k(2,2).c(2) \; \ldots . k(2,n).c(n) &= a(2) \\ &\vdots \\ k(n,1).c(1) + k(n,2).c(2) \; \ldots . k(n,n).c(n) &= a(n) \end{aligned} \quad \ldots (7)$$

which fortunately becomes in matrix terminology

$$\mathbf{Kc} = \mathbf{a} \quad \ldots (8)$$

where **a** and **c** are column matricies and **K** is an n x n matrix. For the two tracer equipment reported here typical volumes of the matrix K were

$$\begin{bmatrix} 600 & 1.4 \\ 175 & 4300 \end{bmatrix} = \begin{bmatrix} k(1,1) & k(1,2) \\ k(2,1) & k(2,2) \end{bmatrix} \quad \ldots (9)$$

where (1) is the notation for the wavelength 525nm, (Erythrosine), and (2) was the notation for wavelength 630nm (Water Blue).

The solution of equation 8 is

$$\mathbf{c} = \mathbf{aK}^{-1}$$

Where $\mathbf{K}^{-1}$ is the inverse matrix of **K**. The problem can be quickly and simply solved for any number of dye components by computer systems that have matrix handling facilities and routines (e.g. Hewlett Packard HP85 fitted with the 15004 Matrix ROM). It is only necessary to measure the absorbance of light at as many wavelengths as dyes used and calibrate each tank solution at <u>all</u> wavelengths used.

SPRAY ACCOUNTANCY

Fig. 1

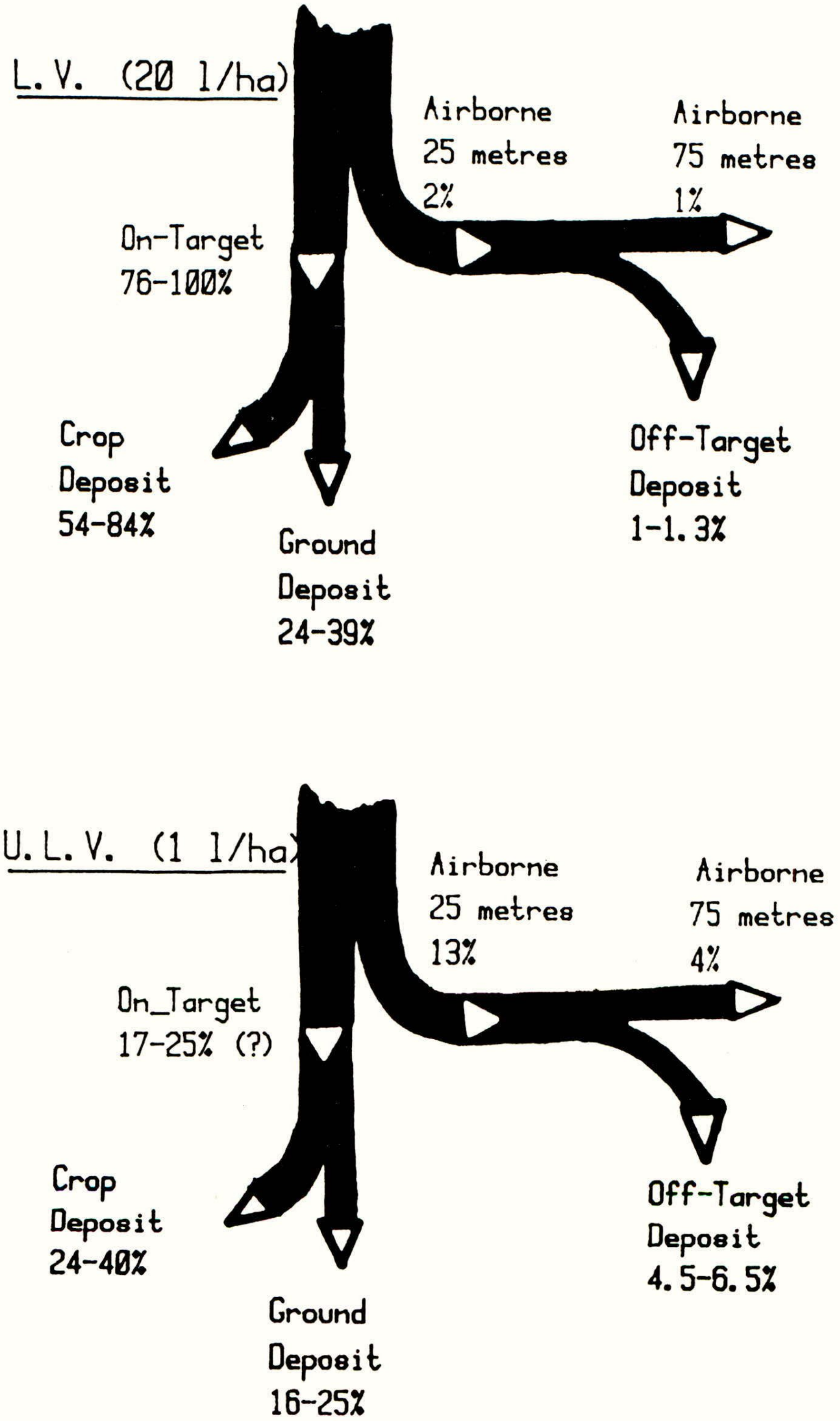

TABLE 1

Summary of meteorological conditions

Experiment	Wind Speed at 11m	Wind Speed at crop height	Wind Direction to flight path
1	2 ms^{-1}	1.5 ms^{-1}	93°
2	3.84 ms^{-1}	2.05 ms^{-1}	87° (± 15°)
3	3.51 ms^{-1}	2.56 ms^{-1}	90° (± 9°)

TABLE 2

Deposit at different heights within a Barley crop

Trial 1

Sample position	Height of deposit in the canopy (h cm)	DUE ml/cm^2 per ml/cm^2 ± 95% limits LV	ULV
Top	20	0.135 ± .031	0.077 ± .027
Middle	7.5	0.070 ± .012	0.046 ± .011
Bottom	0	0.067 ± .013	0.046 ± .012
Ground	0	0.595 ± .229	0.124 ± .142

Trial 2

Top	54	0.225 ± .065	0.134 ± .033
Middle	27	0.061 ± .015	0.041 ± .036
Lower	10	0.061 ± .017	0.045 ± .014
Bottom	0	0.011 ± .032	0.072 ± .031
Ground	0	0.319 ± .092	0.205 ± .057

Trial 3

Top	56	0.158 ± .034	0.056 ± .018
Middle	28	0.041 ± .001	0.019 ± .005
Lower	11	0.063 ± .018	0.034 ± .013
Bottom	0	0.069 ± .021	0.043 ± .012
Ground	0	0.390 ± .123	0.150 ± .018

SURFACTANTS, DROPLET FORMATION AND SPRAY RETENTION

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INTRODUCTION

A progressive decrease in vmd and an increase in foliar retention were found to occur when increasing amounts of the non-ionic surfactant Triton N150 were added to a hydraulic spray (Anderson *et al*. 1983). These effects were explained in terms of dynamic surface tension. Spray retention and vmd have now been determined for water, three non-ionic polyethylene oxide surfactants Agral 90, Triton N150 and Texofor 85 and two anionic surfactants, Manoxol OT and sodium dodecyl sulphate (SDS).

METHODS

A hydraulic nozzle ('Spray Systems' 11003) operating at 300 KPa was passed over trays of outdoor grown pea plants (cv. Meteor) with non-reflecting targets placed at each end of the tray. Deposits were quantified by spectrofluorimetry. Retention was calculated on a leaf area basis. Droplet size distribution and vmd were determined using the 'Malvern' particle size analyser.

RESULTS AND DISCUSSION

Surfactant effects on vmd

Decreases in vmd's depended on surfactant concentration. Vmd's were up to *c*. 20% smaller than that of water (200 μm) for the non-ionic surfactants and up to *c*. 30% smaller for the anionic surfactants. Reductions in vmd would be expected to lead to some increase in retention, but also to increase the proportion of spray volume forming small droplets (< 70 μm diameter), which, in the field could lead to increased spray drift.

Surfactant effects on spray retention

Retention varied between batches of plants e.g. from 24 to 53% for 1.0 g/l Triton N150. Retention relative to 1.0 g/l Triton N150 ranged from 0.24 (water) to 1.38 (2.0 g/l SDS). At a given concentration ($g\ l^{-1}$) the anionic surfactants gave a greater spray retention than the three non-ionic surfactants and this parallels their ability to reduce surface tension rapidly (Thomas and Hall, 1979).

In field use the differences between these surfactants are unlikely to be significant, but the inclusion of sufficient surfactant (> 1.0 g/l) to ensure reasonably efficient retention of sprays, particularly on highly reflective leaves such as brassicas and pea, is important.

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THE SAFETY AND EFFICIENCY OF CHEMICAL TRANSFER SYSTEMS

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The theme of this Symposium revolves around Dr Chester Himmel's remark that "Agricultural Spraying is the most inefficient Industrial Process on Earth". The truth of this contention is supported by the knowledge that only 1% or 2% of Pesticide Application is biologically functional (Graham-Bryce 1977, et al).

This being so, if one takes the view that the efficiency of the Transfer process of Pesticide from spray tank to biologic target is substantially related to the safety of that process - for, as with any hazardous material, what is 'lost' during a process must necessarily be contaminatory in one form or another, then the need for improvement in efficiency as a prime component of safety must become of paramount importance if the Industry is not to become vulnerable to environmentalist criticism.

That, in this context, our present methods of applying Pesticide are in the region of 98% inefficient would also, as a corollary, indicate considerable technical scope for improvement in application efficiencies.

The intent of this Poster Display Abstract is to briefly present the approach of a small Spraying Equipment Manufacturer to development parameters aimed at improvement in The Physical Aspects of Pesticide Transfer.

PHYSICAL ASPECTS OF PESTICIDE TRANSFER

Problem

As much as 70% of spray applied through hydraulic pressure nozzles may be lost (Matthews 1982).

Cause

Very wide variation in droplet sizes produced by this method, resulting in loss of large droplets to ground, small droplets to aerial drift.

Answer

Control of droplet size with a high degree of droplet size uniformity: Controlled Droplet Application.

CDA Problem

a. Insufficient volume capability for some Pesticide and Liquid Fertiliser application situations.

b. Lack of droplet penetration.

c. Irregular desposition due to wind variables.

Technological Response

a. The development of a Rotary Atomiser capable of from Ultra Low Volume to High Volume range of Controlled Droplet Application.

b. Development of a system providing controlled air impulsion and guidance of CDA droplets and imparting vertical droplet flight trajectory to counter sideways wind vector droplet displacement and the effect of wind variables. Air impulsion velocity range requirement sufficient to move foliation deep within canopy for upper and lower leaf surface droplet deposition. The provision of air impulsion should be such that the integrity of droplet formation at the Rotary Atomiser is not disrupted by air blast velocity.

Development Status

a. Ultra Low volume to High volume Rotary Atomisers now developed, with a CDA range of 4 litres/hectare to 500 litres/hectare at 4 mph. Selectable CDA droplet size range from 100 to 600 micron.

b/c. Controlled Droplet Air Impulsion and Guidance Systems are in an advanced stage of development.

SUMMARY

The essence of Pesticide Application efficiency and safety is control. Control of Droplet size to eliminate unusable and, therefore, undesirable droplets: Control over the number of those droplets by a wide volume of application range to provide the required droplet deposition coverage in all situations, combined with control over the direction and velocity of droplet trajectory, would all add up to substantial improvement in application efficiency and, therefore, safety.

REFERENCES

Graham-Bryce, I J (1977). Crop protection: a consideration of the effectiveness and disadvantages of current methods and of the scope for improvement. Philosophical Transactions of the Royal Society of London, Series B, 281, 163-179.

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