COMPARISON OF CDA AND CONVENTIONAL SPRAY BOOMS FOR APPLICATION OF PESTICIDES TO PASTURE

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Summary

Pesticide residue deposits were compared from a conventional spray boom set to deliver 300 litres/ha of carrier and a controlled droplet application (CDA) boom set to deliver 30 litres/ha or 3 litres/ha. All systems gave less than 50% of the theoretical deposit on filter papers placed at ground level. Conventional and high volume CDA gave similar mean deposits while low volume CDA gave a significantly lower amount ($P < 0.01$). For applications to pasture, high volume CDA was superior, and gave double the mean deposit found for conventional and low volume CDA. Conventional applications gave less variable deposits than CDA.

INTRODUCTION

Compared with the large expenditure devoted to the development and evaluation of pesticide chemicals, relatively little attention has been given to application methods. Pesticides are commonly diluted in relatively large volumes of water and pumped through hydraulic nozzles to provide a spray with a very wide range of droplet sizes (6-400 µm diam.) (Bals 1978a; Matthews 1979). This wide range of droplet sizes can be very wasteful; small droplets drift away and may not impinge on the target (Bals 1969), while large droplets may run off and be effectively lost. In order to improve the efficacy and efficiency of chemical pest control, there is a need to develop application techniques which increase the proportion of the emitted chemical deposited on the biological target. Developments have been made with controlled droplet application (CDA) by spinning discs, both alone (Bals 1969, 1978b), and in combination with electrostatic forces (Arnold 1979), and by using electrodynamic energy (Coffee 1979). The potential advantages of such systems include, choice of appropriate droplet size to suit the crop and target pest, reduction of uncontrolled drift, increased tolerance to wind (Adams 1978), reduction in carrier rate and hence decrease in total application time, and possible reduction in pesticide application rate.

In this study, we have constructed a spray boom of spinning disc CDA units according to specifications supplied by the manufacturers. We have then examined the suitability of this boom for the application of pesticides to pasture, and compared the results with those obtained with a conventional hydraulic fan-jet spray boom.

METHOD

Conventional boom

The conventional sprayer consisted of a galvanised iron boom mounted on arms extending 800 mm behind the rear of a "Land Rover". The boom (5.5 m long) was fitted with 15 flat spray tip nozzles (730308) spaced 375 mm apart (swath width 5.6 m). Each nozzle was supplied with a 100 mesh strainer and a check valve. A roller bearing pump delivered the spray mix from the tank through a filter and pressure regulator to maintain a boom hydraulic pressure of 275 kPa. Output was 1.07 litres/min/nozzle and vehicle speed was 1.6 m/sec. Nozzle height above ground level was 600 mm.

Application and Techniques

CDA boom

For CDA application four "Micromax" units (Micron Sprayers Limited, Bromyard, England) were mounted, 1.8 m apart (giving a swath width of 7.2m) on the same boom as that used for conventional spraying. The spray mix was delivered by a "Mistifier" pressurised tank via a line which included an inline filter (100 mesh), a diaphragm pressure relief valve (set at 69 kPa) and a pressure gauge (0-400) kPa. A 12 volt solenoid valve with additional filter and check valve and a flow regulator fitted with an interchangeable orifice plate (to allow a range of flow rates to be used) was situated adjacent to each CDA unit. The line from each flow regulator then passed via a T-junction to two large-hole (red) nozzles mounted on the "Micromax" unit. Small diameter hose (9 mm ID) and tubing (5 mm ID) were used to avoid wastage of the spray mix. Power connections were made from the electrical system of the vehicle.

Spray droplets were produced from the periphery of the spinning discs in the units at about 550 mm above ground level. For large droplets, an output of 830 ml/min/disc (Spray Systems orifice plate 4916-55 fitted in the flow regulator) was used with low disc speed (*ca.* 2000 rpm). Vehicle speed was 2.6 m/sec. For small droplets, the output was 58 ml/min/disc (plate with 0.37 mm orifice fitted in the flow regulator) with high disc speed (*ca.* 5000 rpm). Vehicle speed was 1.8 m/sec. The addition of 25% by volume of an oil based anti-evaporant carrier (BP N.Z. Limited) to the spray mix did not affect the output.

Variability of deposit within swath

A test spray lane (7.2 m wide) was set up on a lawn mown to 20-30 mm. Lindane was applied at 10 g/ha using each of five spray systems.

A. Conventional with 300 litres of water/ha;
B. CDA with 30 litres of water/ha as large droplets;
C. CDA with 30 litres of 1:3 anti-evaporant-water/ha as large droplets;
D. CDA with 3 litres of water/ha as small droplets;
E. CDA with 3 litres of 1:3 anti-evaporant-water as small droplets.

Five rows of filter papers (Whatman No. 1; 90 mm diam. held in 90 mm diam. petri dishes) were set up across the test lane. The rows were approximately 2.5 m apart and contained 10 filter papers each, spaced at 0.8 m intervals. The spray vehicle was driven down the centre of the test lane, thus the CDA boom was expected to cover the full row (10 papers) while the conventional boom was expected to cover the inner eight papers only. There were two runs of each spray system on each of two spray days. After each run, the petri dishes containing the filter papers were collected and stored at 0 °C before chemical analysis. The expected lindane deposit on each paper was 6.4 µg.

The weather conditions were similar on both test days; temperature, 27-30 °C; relative humidity, 38-45%; wind, 0.6-1.1 m/sec generally across the direction of travel, but variable.

Application to pasture

This trial compared the effectiveness of spray systems A, B and E for application of lindane (40 g/ha) to pasture. Two separate test srips (10 m long) were treated for each spray system on both long pasture (150 mm; dense and fallen over, containing a large amount of clover) and short pasture (up to 100 mm; mixed ryegrass, paspalum and white clover). Herbage samples were cut with hand shears from 200 x 200 mm squares at 10 randomly selected points within each test strip. The top half and lower half from each point was collected into a separate bag. Herbage samples were stored at 0 °C before analysis, and each sample was analysed seprarately. The approximate total residues expected (tops plus bases) were 5 mg/kg on the longer pasture and 7 mg/kg on the shorter pasture.

The temperature during the tests was 20-26 °C, with wind directly opposite the direction of travel at 1.4-3.2 m/sec (long pasture) and 1.3-1.8m/sec (short pasture).

Droplet sizes and surface cover

The actual droplet sizes produced by spray systems B and E were measured as outlined by Matthews (1975). The average of 22 droplets from each of five sampling slides was determined for each spray system. Applications were made in calm conditions at 14-17 °C.

An estimate of the surface cover from each of the five spray systems was made simultaneously with the filter paper tests. Sheets of photographic paper were used to record the droplet distribution and numbers reaching the surface.

Chemical analysis

Lindane (20 EC : ICI Tasman Limited) was used as a marker because of its high sensitivity by electron capture gas chromatographic detection. Residues were analysed by standard techniques.

Residues on filter paper were determined by placing each paper in 80-100 petroleum ether (10 ml), agitating, then standing overnight before analysis. Recovery under these conditions was 80% and values are uncorrected.

Residues on foliage were determined by taking one 10 g subsample from each bag of grass (or the total when less than 10 g was collected) and shaking (1 min) with a 3:2 mixture of 80 - 100 petroleum ether-acetone (50 ml). The total extract was washed with water (150 ml) and aliquots of the resulting organic layer were used for analysis by gas chromatography. Recovery was 80% and values are uncorrected.

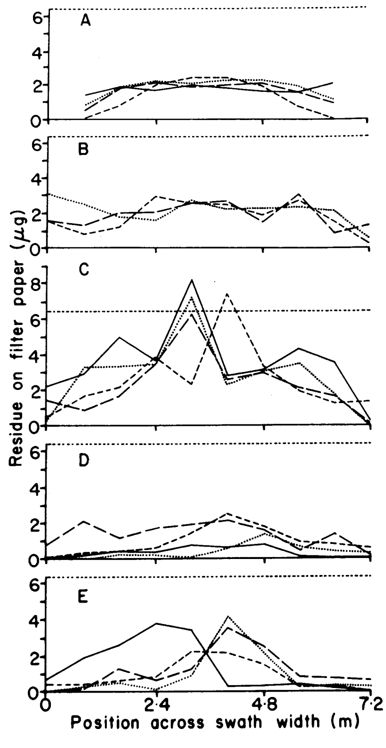

Fig 1. Mean lindane deposit across the swath of five different spray systems. Figures are drawn from the swath positional means for each of runs 1 (----) and 2 (— — —) (first day) and runs 3 (———) and 4 (.....) (second day). System B, run 3 included an application error and is therefore omitted.

RESULTS AND DISCUSSION

The results of the filter paper experiment are summarised in Table 1 and Fig. 1. It is clear that none of the spray systems came close to depositing the theoretical application of 6.4 μg under our test conditions. Also, all systems deposited less at the edges of the swath width than in the middle (P◄0.01), although no attempt was made to determine what would be the affect of overlap of adjoining passes in the practical situation. We do know, however, that for the conventional boom, almost nil deposit was found at points 0.8 m beyond either end of the theoretical swath width.

The highest mean deposit was given by system C (large droplet CDA with 25% anti-evaporant carrier). However, since the general use of an oil based carrier for applications with large droplet sizes would not be cost effective (Bals 1978a), this system was not examined in later tests. Spray systems A and B showed similar mean deposits on the filter papers; significantly less than from System C, but significantly more than from D and E (P◄0.01). Systems A and B were actually compared for application of synthetic pyrethroids to closely grazed sheep pasture for adult grass grub *(Costelytra zealandica)* control. Slightly higher chemical residue was found on the pasture with the CDA application, but despite this, no difference was found in the rate of control achieved (authors' unpublished results).

TABLE 1: Lindane deposits on filter papers using five different spray systems

System	Mean deposit (µg) Inner[1]	End[2]	CV[1] (%)	Range[3] (µg)	Droplet[4] (µm)	Cover[5] (drops/cm^2)
A	1.9	0.9	25	0.7- 3.2	nd[6]	na[6]
B	2.1	1.4	44	0.4- 4.4	273	15
C	3.3	0.8	65	0.4-13.5	nd	18
D	0.9	0.3	100	0- 4.4	nd	9
E	1.3	0.3	122	0-7.5	109	10

1 Calculated from all filter paper determinations for the four runs of each spray system excluding all replicates from the positions at the ends of the expected swath widths.
2 Mean of the 20 filter paper determinations for the positions at the ends of the expected swath widths.
3 Full range of deposits on the filter papers for the inner boom.
4 Average experimentally determined droplet sizes.
5 Expected values are 28 and 44 for the 273 µm and 109 µm droplet sizes respectively.
6 nd = not detemined; na = not applicable.

Spray systems A and B showed less variation in deposit than did systems C, D and E (P◄0.01). This is reflected in the CV values shown in Table 1. Also, as Figure 1 shows, systems A and B gave less variation in the mean deposit across the boom than did the three other systems. A and B gave a similar level of deposit across the swath with B giving a slightly wider range of variability at individual points. System C gave a generally higher deposit across most of the swath, and also gave some very high values, particularly in the mid-region of the boom where four individual readings of double the theoretical application were recorded. Coverage and distribution from systems D and E were generally poor. The low deposit from these systems may be explained partly by drift. It is also possible that the wind eddies created by the vehicle could inhibit the smaller particles from collecting on the filter papers and in fact swirl them up into the air. Under the atmospheric conditions of the first test, once airborne, 100 µm water droplets would have a lifetime of only 14 secs (Lofgren 1969), and could travel at least 15 m (Matthews 1975).

Fewer drops were recorded on the photographic paper than was expected; 54% of the large droplets (B) and 23% of the small droplets (E) were recovered. These figures are of the same order as the residue recovery (33% and 20% respectively), and show the failure of all CDA systems (as well as the conventional) to deposit a significant percentage of the emitted chemical on the target.

The results of the pasture spraying experiments are summarised in Table 2. The large droplet CDA system, B, gave about twice the deposit of the conventional system (P◄0.01), but still only about half the theoretically expected deposit of 5-7 mg/kg. The small droplet CDA system (E) performed relatively better in the pasture trial than in the filter paper test and only slightly less deposit was found ***overall*** than for the conventional boom. Apparently, the pasture affords a better surface for collection of the small particles than does filter paper (cf. Bals 1969; 1978b). However, the smaller droplets had less penetration into the base of the pasture than either of the two other systems (P◄0.01). Deposits from the conventional system were generally less variable than from either CDA system (P◄0.01).

In the course of these residue studies, a field trial comparing the low volume CDA and conventional systems for the application of a systemic insecticide against bluegreen lucerne aphid *(Acyrthosiphon kondoi)* on actively growing lucerne *(Medicago sativa)* (100-150 mm height) was carried out. Both systems were equally effective in controlling aphids (authors' unpublished results) as might be expected from the results reported in Table 2. In retrospect, Table 2 shows that the efficiency of these aphicide treatments could have been improved by using the large droplet CDA system.

TABLE 2: Lindane deposits on pasture using three different spray systems

System	Mean deposit[1]		CV[2] (%)
	Tops	Bases	
A	1.40	1.13	36
B	2.89	2.02	59
E	1.44	0.74	67

[1] Expressed as mg/kg of fresh foliage. Since no significant differences were found between deposits for different runs or pasture lengths with the same spray system, values have been presented as the overall means.

[2] Combined value for both tops and bases.

CONCLUSIONS

Various experiments have been reported that suggest that CDA may (FRI 1978) or may not (Phillips 1978) be more efficient than conventional spray systems. Our experiments have been designed to determine the effectiveness of the different spray systems to deposit chemicals on short to medium length pasture surfaces, and should be interpreted with this in mind. The ideal droplet size and spray system will vary according to the type and habit of the pest involved (Bals 1969). Our results suggest that providing the correct CDA system is chosen for the job in hand, results at least comparable to those obtained with conventional systems should be possible. An additional advantage of the CDA system is the use of lower spray volumes. Fewer tank refills would mean that large areas could be treated more rapidly, an important consideration in pest control methods where timing of application is critical.

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