3 SPRAY DRIFT CAPTURE BY PLANTS

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3.1 INTRODUCTION

Williams *et al.* (1987) reviewed the literature on deposition of droplet drift on vegetation. Deposition is not evenly distributed over downwind vegetation but tends to be concentrated on certain plants and plant parts because of differences in their shape, position and surface texture. This is important not only in determining the damage caused by herbicides but also the vulnerability of any insects present to insecticides. Actual data on deposition are almost entirely confined to crop plants but one can predict that:

1) Plant parts with a rough micro-topography, because of raised views, hairs etc will collect more drift than smooth ones, especially small droplets (<100 µm) (Uk 1975, 1977). On the other hand, waxy surfaces and dense pubescence may make leaves more difficult to wet, and large droplets will tend to run off.

2) Small, narrow or finely divided plant parts will collect drift more efficiently than thick stems or broad, simple leaves, provided that the surface characteristics are similar (Tu, Lin & Zhang 1986; Chamberlain 1975).

3) Where there is a more or less continuous canopy of herbaceous vegetation, drift deposition per unit area will be greatest near the top of the canopy (Callander & Unsworth 1983; Payne 1983).

4) Deposition on particular plant surfaces can be profoundly modified by the use of wetting and sticking agents and electrostatic charges (Hartley & Graham-Bryce 1980; Byass, Lockwood & Andrews 1979; Allen *et al.* 1991).

Spray deposition on target leaf surfaces has been studied mainly with the use of tracer dyes. The distribution and/or number of droplets are observed by eye (Barnett 1991; Clayton & Bals 1991) or photographed and measured with an image analyser (Raisigl *et al.* 1991), or the total deposition is rinsed off and measured by a spectrophotometer (Cross 1991). These techniques were considered in 1989 at an Association of Applied Biologists workshop on The Use and Limitations of Tracers for the Qualitative and Quantitative Assessment of Agriculture Spray Deposits. The droplet measurement system described there by J V Cross for apple leaves, and further developed by him since then, was adapted for the present work. However, this required considerable development in methodology and image analysis. This report, therefore, only provides the basis for further work that would be needed to establish meaningful results in relation to the variables of practical interest.

3.2 METHODS

Different species of plants are likely to vary in several ways with respect to spray drift capture. It was initially decided, therefore, to compare deposition on leaves in relation to particular contrasts a) heights (upper v. lower culm leaves), b) shape (broad v. narrow), c) orientation (vertical, oblique, horizontal), d) texture (smooth v. rough or hairy). The methodology for making these comparisons is described under five headings: 1. Choice of a fluorescent dye. 2. Development of a simple 'laboratory' spray regime. 3. Choice of plant species. 4. Photography of sprayed leaves. 5. Image analysis.

3.2.1 Choice of fluorescent dye

A wide range of fluorescent pigments is now available. Fluorescein, which was successfully used with artificial receptors in the study of hedge effects on drift (Section 6) was unsuitable for the present work because of rapid absorption onto vegetation and fade under UV light. Cross (1989) and Jegerings & Cowell (1989) described the use of Sunset Yellow and Lunar Yellow for examining surface deposits as they are persistent and light stable but they, and a similar dye Solar Yellow which was tried, have low solubility and tended to clog spray nozzles. Tinopal was therefore used in this study at 2% concentration. Its disadvantage is that it fades in sunlight and is less suitable for outdoor use.

3.2.2 Spray regime

A prototype spray regime was set up in an enclosed, darkened garage. This used a greenhouse handspray at a fine spray setting directed obliquely down towards a fixed point into a steady airstream from an Xpelair-taurus fan 90 cm above floor level. Target leaves were held by small bulldog clips on a retort stand level with and at distances between 1.6 and 3.2 m from the fan. Initial trials used leaves one at a time but in later comparisons two or more leaves were used side by side, one above another or at two distances simultaneously. After spraying, the leaves were kept in closed boxes until photographed.

3.2.3 Choice of plant species

The choice of plant species was constrained by local availability and the need for relatively flat leaves that would lie easily in a focal place for photography. Very small, narrow and finely divided leaves were also unsuitable for this technique because deposition was calculated on a standard unit area basis (see 3.2.5 below). Table 3.1 lists the species used and their characteristics.

3.2.4 Photography of sprayed leaves

A special light box was constructed based on that used by Cross (1989) but with less powerful flash guns and compensatingly faster film. The unit consists basically of a triangular box with a camera and extension ring mounted at the apex, and a pair of flash guns mounted on the sloping sides to illuminate a withdrawable plate lying in the focal plane of the camera. The coated front glasses of the flash guns are removed, ultraviolet-transmitting filters fitted in front of 11the flash guns to cut out visible light, and an ultraviolet-absorbing filter fitted in front of the camera lens (Table 3.2).

Sprayed leaves are placed on the removable plate and held in position by another plate with a rectangular hole cut in it. UV light emitted by the flash guns is converted into visible fluorescence by the spray deposits, while the rest of the leaf remains dark. High contrast transparency photographs are taken and are readily subject to image analysis. After the first two trials, three or four replicate leaves were sprayed and two or three photographs were taken of each leaf to bracket the correct exposure time. During teething troubles with this apparatus, the original light box was borrowed and several experiments were conducted using this.

3.2.5 Image analysis

In the absence of a custom-built image analyser, a programme was written for a Kontron-IBAS Macro computer at the British Geological Survey, Keyworth. The photographic transparencies were viewed with a Zeiss universal photo microscope at x 1.25 magnification lit from below. This gave a field of view of 5 x 5 mm. The image from the microscope was captured on a Sony video camera, digitised by a video multiplexer and stored on the computer. Grey level thresholds were pre-set at 130 and 255 so that pixels falling within this range were classified as "white" and those outside the range as black. The Tinopal deposits were clearly defined and background light intensity could be controlled by adjusting the light entering the microscope. Three or four separate measurements were made for each leaf. The results were saved as an ASCII file onto a floppy disk and analysed on a VAX computer at Monks Wood. Full details of the "Leafspot" programme are given as Appendix 1 to this report.

3.3 RESULTS AND DISCUSSION

Seven trials were conducted using this system, summarised in Table 3.3. However, image analysis was only carried out on three of these. Total deposition values of 3-11% cover were comparable with results obtained by Cross (1989) for orchard spraying with very low volume sprays.

Trial 3 (Table 3.4) showed no effect of texture on total deposition or mean spot size, but there was significantly less deposition at 3 m than at 2 m. Trial 4 showed a significant effect of leaf orientation on mean spot size (Table 3.5) but the lowest value was at intermediate orientation which is difficult to interpret. There was no significant difference in deposition or spot size over the height range considered for *Carex* (Table 3.5).

It became obvious from these preliminary results that a large amount of replication would be needed to overcome inherent variability within each leaf category and between successive sprays to show significant differences. This was beyond the resources available for this work. A precision sprayer is needed to give accurately repeatable doses (VMD and total spray) into a steady airstream. The Kontron-IBAS system provides a powerful research tool for analysing droplet size, number, shape, orientation and total area, but it is slow to use compared with a custom-built equipment such as an Optomax or Quantimet image analyser, taking days rather than hours to process a large batch of photographs. In comparing the efficiency of different nozzles for spray deposition on apple leaves Cross (1989) used samples of 250 leaves.

The conclusion from this work is that the photographic approach can provide much information on the distribution of drift deposition on leaves. Further work with suitable replication and image analysis would allow meaningful comparisons of leaf position and texture as described above, and provide a firm basis for general principles. However, this approach is less suited to comparing whole plants with very different leaf morphology, such as *Lychnis* (smooth culm leaves) *Plantago* (hairy rosette leaves), *Achillea* (finely divided leaves)

Table 3.1. Leaves used in spray capture trials showing surface characteristics. Upper surfaces except where labelled L, N = narrow (c. 20 mm) linear leaves with parallel veins, S = only used in pilot trials with Solar Yellow.

Very smooth, hairless	Moderately smooth, hairless	Moderately hairy	Very hairy
Calystegia sepium	*Acer campestre* S	*Centaurea nigra*	*Heracleum sphondylium* S
Carex pendula N	*Carex pendula* L N	*Corylus avellana*	*Stachys sylvatica*
Sonchus arvensis	*Cornus sanguinea* S	*Plantago lanceolata* N S	*Tussilago farfara* L
Tussilago farfara	*Fraxinus excelsior*	*Silene dioica*	

Table 3.2. Specifications for ADAS (a) and ITE (b) light boxes and photography of sprayed leaves.

Flash guns	a) Metz Mecablitz 60 CTI b) Cobra Auto 250
Camera	SLR with flash synchronisation, 28-32 mm extension ring and cokin filter ring
Filters	Four 50 x 50 mm Hoya U340 (UV transmitting) One 50 x 50 mm Hoya L42 (UV absorbing)
Film/aperture	a) Kodachrome 64 F5.6/8 b) Ektachrome 400 F4/5.6

Table 3.3. Spray drift comparisons: design of 7 trials with Tinopal.

Trial	Variables
T1, 2	3 species x 3 distances x 4 camera exposure times
T3	6 species[1]: 2 textures[2] x 2 distances x 3 replicates
T4	3 species x 3 orientations[3] x 4 replicates
T5, 6	3 species x 4 heights[4] x 2 distances x 3 replicates
T7	2 species x 2 orientations[5] x 2 surfaces[6] x 4 replicates

(1) *Tussilago* upper and lower surfaces counted as 2 species
(2) smooth and hairy, see Table 3.1
(3) vertical, horizontal and 45° (leaf tip pointing away from fan)
(4) 15, 30, 45 and 60 cm (fan centre at 45 cm)
(5) horizontal and 45° (leaf edge facing fan with tip towards left)
(6) upper, lower

Table 3.4. Analysis of variance of spray deposits for trial T3. Comparisons of mean % cover and mean spot size (μm) for variations in leaf texture and distance from fan. (L = lower surface).

		% Cover Distance (m)			Spot size Distance (m)		
Species	Texture	2	3	Mean	2	3	Mean
Tussilago	Smooth	6.70	0.91		58	38	
Carex	"	2.73	2.55	3.02	14	35	40
Sonchus	"	3.27	1.96		36	60	
Tussilago L	Hairy	5.88	0.52		58	26	
Silene	"	1.34	3.10	2.91	21	57	47
Centaurea	"	4.88	1.75		51	68	
Mean		4.13	1.80		40	47	

		ANOVA % cover				ANOVA Spot size
Source	DF	SS	MS	F	P	P
texture	1	0.107	0.107	0.02	0.900 NS	0.345 NS
distance	1	49.139	49.139	7.39	0.010 **	0.294 NS
error	33	219.315	6.646			
Total	35	268.561				

Table 3.5. Analysis of variance of spray deposits for orientation and height trials T4 and T5 (part).

T4	% cover				Spot size (µm)			
Species	Vert	45°	Hor	Mean	Vert	45°	Hor	Mean
Sonchus	9.71	7.33	11.22	9.42	68	53	90	70
Lychnis	7.77	4.57	6.50	6.28	58	45	90	64
Stachys	11.27	3.49	4.66	6.47	98	75	93	88
Mean	9.58	5.13	7.46		75	58	91	

	ANOVA % cover		Spot size	
	F	P	F	P
orientation	3.22	0.054 NS	6.30	0.005 **
species	2.01	0.151 NS	3.61	0.039 *

T5 Carex only	Height (cm)				ANOVA	
	15	30	45	60	F	P
% cover	3.77	4.34	3.32	2.19	1.14	0.39 NS
spot size (µm)	23	20	20	13	3.17	0.085 NS

and *Galium* (whorls of small leaves), or for examining the distribution of spray deposition over stems, leaves and flowerheads of individual plants. The use of a dye which can be rinsed off and measured is more suitable for the latter approach (see Cross 1991), although suitable means would have to be developed for standardising samples in relation to unit surface area. Separate studies would be needed to compare different commercial sprays which were designed to adhere to particular plant surfaces. Field experiments would ultimately be needed to study spray drift capture of different species in mixed swards.

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