Techniques for measuring
Spray drift

1 Introduction

Environmental concern has stimulated a need to reduce off target contamination with pesticides. Techniques, formulation changes and other aspects of pesticide use are generating methods by which drift as spray droplets can be reduced. A standard method for measuring spray drift is surprisingly not yet advocated by independent or regulatory bodies but is needed if advancements in spraying are to be propely quantified. Consideration should be given to the siting of experiments with spray drift, the colecting target, measurements of spray deposit, the spray target, pesticide formulation and experimental procedures.

2 The origins of spray drift

Drops with low momenta may have inadequate inertia to take them from source of formation to the target surface (Fig 1). They become entrained in ambient wind to be transported out of the treatment zone (Fig 2). Conditions associated with worsening drift include - use of small drops, long flight trajectories when boom is used too high, high wind speeds, fast spraying speed and high ambient temperatures that may both reduce drop size still further through evaporation and cause thermal 'Iifts'. The prime formation of small drops from hydraulic nozzles is associated with narrow orifices - used for both low outputs and wide spray angles, and high pressures.

3 Siting of field experiments

Drift evaluations could be done under the controlled conditions of the laboratory if it was certain that the relationship between drop size/momenta and drift was simple. In practice, the relationship is complex because of the interaction with 'field' variables that may have major effects. In consequence, field measurements are preferred where meteorological conditions and target site are carefully recorded, to be supplemented with laboratory data on drop size/speed. To minimise the impact of field variables such as wind turbulence, the experiments are sited in open areas away from hedges/trees. Drift measurements are often made with the wind blowing across the boom - the situation that has been assumed to produce most drift and be more consistent. When wind speed is the experimenal variable, the fields used should have comparable crops/soil surfaces for it is likely that quantities of spray drift may be less when making measurements where there is an open surface such as in the presence of a crop.

4 Drift targets

A balance has to be made between using targets that are large enough to collect representative samples yet not interfere with the passage of air, and are effective for trapping very small inflight drops. In addition, sampling the moving spray cloud at enough points and positions to reflect its size and density demands the targets be positioned in 3-dimensions. For example, some researchers (Gilbert,K) use masts 10 m high and position them from boom tip to 200 m downwind. Thin (2 mm wide) plastic tube is stretched horizontial and vertically at varying set heights to permit sampling at all points of the imaginary line along the spray drift cloud. Other researchers may use complex target shapes (Fig 3-4**)** with many external narrow points to increase small drop impaction (Bury,1987). Such targets passively sample the moving spray cloud.

Consideration to drop impaction efficiency must be made, for small air borne drops are readily blown around - rather than onto - some shapes/surfaces. Glass plates fixed horizontally and/or vertically possibly only capture drops with adaquate momenta. Spray machines with drops entrained in fast directed air would exasperate such an effect if sampling within the machines immediate vicinity. In some instances, the cloud may be actively sampled using targets such as straws or wires - rotating on a motor. Spray drift laden air has also been sucked through filters that trap the drops for later analysis. Sampling positions should be at all points from within the drifting spray cloud so that its extent and intensity are truly known - too low sampling and one may only record the lower portions of the cloud and miss the centre.

5 The application

Drift often only results in very small quantities of spray being air borne. To both reduce the variability in deposit on the drift collectors and increase measured values, several swaths may be sprayed using the same tracks (for comparative studies) or sequential ones (for field drift losses) (Fig 5).The distance sprayed up to and beyond the sampling targets needs to ensure the spray cloud is fully developed before, and slight variations in wind direction are considered. Typically a minimum of l00 m run is used.

Note should be made of application related issues such as spraying speed, nozzles and boom width. Wind strength (usually at 2 m height) and direction must be recorded before, during and after the spray runs.

6 Quantifying drift deposits

Deposits may be assessed on measurements of the active ingredient or tracers often as colourometric or fluoriometric dyes. Time to extract, prepare and measure active ingredients often limit their general use when making measurements based on large numbers of samples. Recently spray drift has been measured with two types of pyretheroids being sprayed simultaneously from the same machine through different drop formation devices but using the same targets downwind. Tracers tend to be preferred in most work but they have limitations - the colourmetric dyes may lack adequate sensitivity whilst the fluorometric may fade. Both may interfere with the formulation. ldeaily the tracer is disolved in the same phase (that is the oil, water or solid phase) as the active ingredient. For example, when tracing an emulsifiable concentrate, the tracer should be in the oil phase of the sprayed emulsion rather than the water matrix.

Water sensitive paper (WSP) may also be used but care must be taken in the interpretation of the results, for air borne drops may blow around the flat capture surface. Drops on impaction change the yellow dye on the paper to blue almost immediately and assessment can be in field or later. Using magnifying glasses with scales or image analysis instrumentation, drop numbers, size (there is a constant spread factor about x 2) and cover can be determined.

Piants and pests sensitive to an active ingredient have been positioned downwind to record the biological consequence of such spray losses. Results tend to be confounded by variabiliy by the plant to often sub-lethal doses. In addition plant response may not record total quantities lost to the environment and in spray accountability studies are of limited value.

7 Comparing some different methods of measuring drift

Drift reports may appear contradictory and it was recently opportune to make a comparison - to check absolute levels and sampling positions, targets, numbers. Two rows of masts were positioned 0.5 m downwind of the boom top (that is 0.0 m at swath limit), 8.0 and 20.0m. These masts were 4m high with small holes drilled at 0.5 m intervals on opposing sides. In these holes were inserted pipe cleaners, to be removed after spraying for analysis. For comparative purposes 2 mm wide plastic tube was hung vertically close to the same masts and alter spraying known lengths taken at similar heights to the pipe cleaners. On further separate masts glass slides were mounted vetically and horizontally from ground level to 3.0 m height - again at 0.5 m intervals. On another separate occasion WSP was positioned as per glass slides.

The tracer/pipe cleaner combinations gave higher absolute values (alter consideration for windward-facing projected plan areas) than the WSP (alter determination by Quantimet) suggesting - but not proving - the pipe cleaners were more efficient for this use. Drift reduction as judged by horizontal WSP was slightly different to that judged by vertical but the mean value was still distant from other techniques.

The tracer/plastic tube method appears comparable to tracer/pipe cleaner in all aspects. Glass slides/tracer gave contradictory results to all others, probably reflecting problems in drift cloud sampling at one low height only.

An overview of much data is near conclusive - that for consistent absolute measurements 'efficient' targets need positioning at least in 3 key positions downwind and need sample up to at least 3 m height. In practice, we position three masts at the swath edge (to quantify the magnitude of spray drift at source), 10.0 m downwind and to establish the spray cloud height and diffusion gradient, collectors are positioned up to 5 metres height..

8 Considerations in the treatment of data

Raw deposit figures are probably as a spray quantity (often microlitres - µl = 1/1.000.000 l) per unit target. Assuming all targets are the same then these figures may be used for comparative work. To derive absolute figures and predict total losses the deposit value need consider plan areas presented (or air volume 'swept'). The original figure now becomes deposit/unit area (for example; $\mu l/cm^2$). Sometimes different spray volume rates need comparisons and when this happens, the data also need consider the total emission and number of spray runs. The data now can be normalised for all comparisons. We thus finally have a figure that may be spray deposit/plan unit area/unit spray volume applied - for example $\mu l/cm^2/100\ l\ /\ ha$.

Copies of papers on spray drift are enclosed in the following:

Taylor and Andersen.
Hardi Ltd Handout
Gilbert A.

Bury, C.J.G: A Komparative study of the drift hazard presented by contrasting ground-spraying systems. 1987
Cranfield lnstitute of Technology M Sc

Tabel 1: Relationship of drop diameter and volume with measured speeds and relative momenta at 0.5 m below nozzle.

Drop diameter, µ	Drop volume, µ	Drop speeds m/sec	Momenta
100	5.24 x 1 0-4	l.6	1
200	4.19 x 10-3	6.2	31
300	l.42 x 10-2	9.7	164

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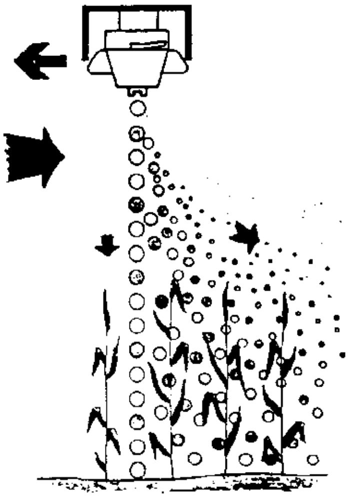
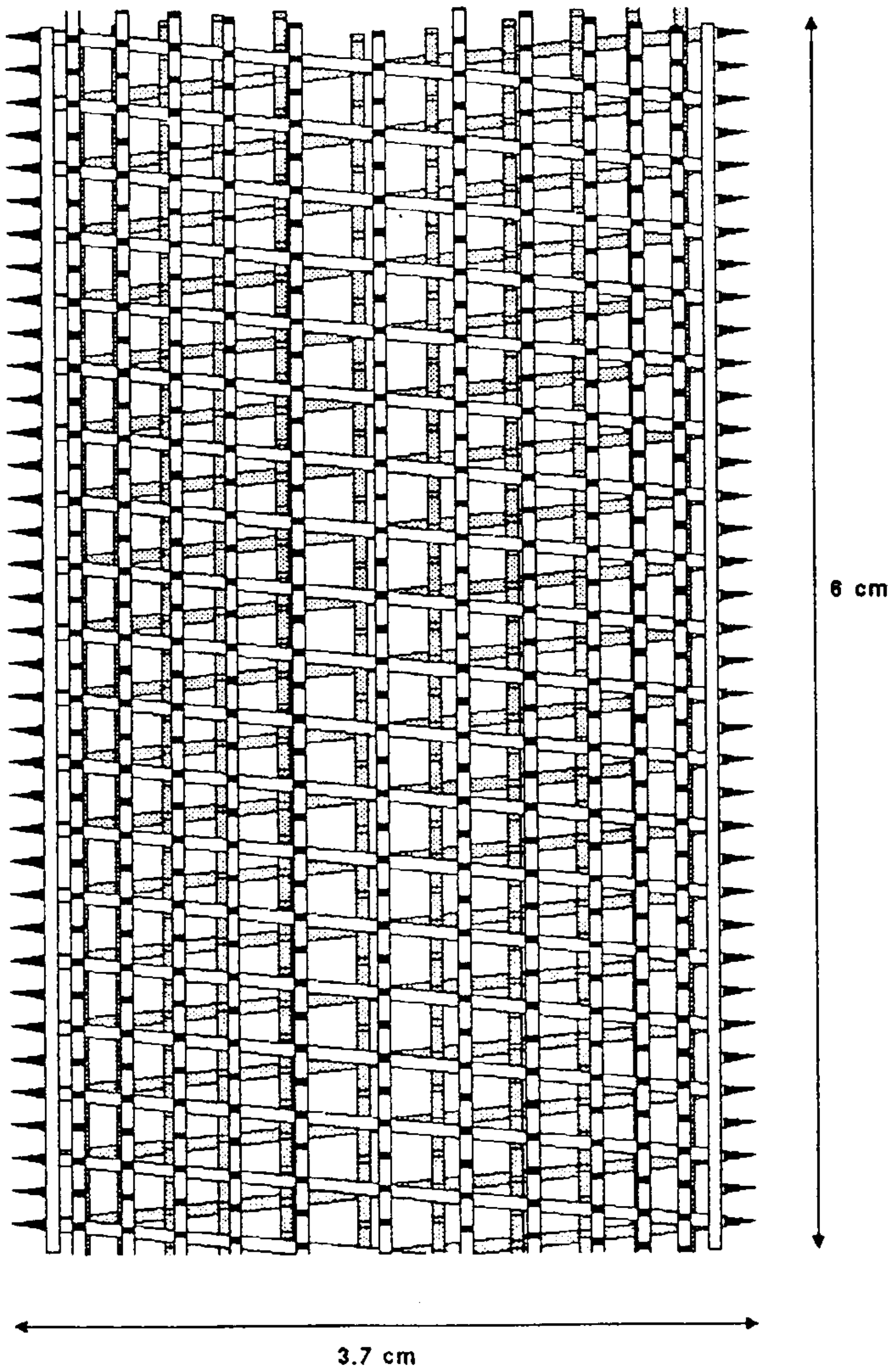
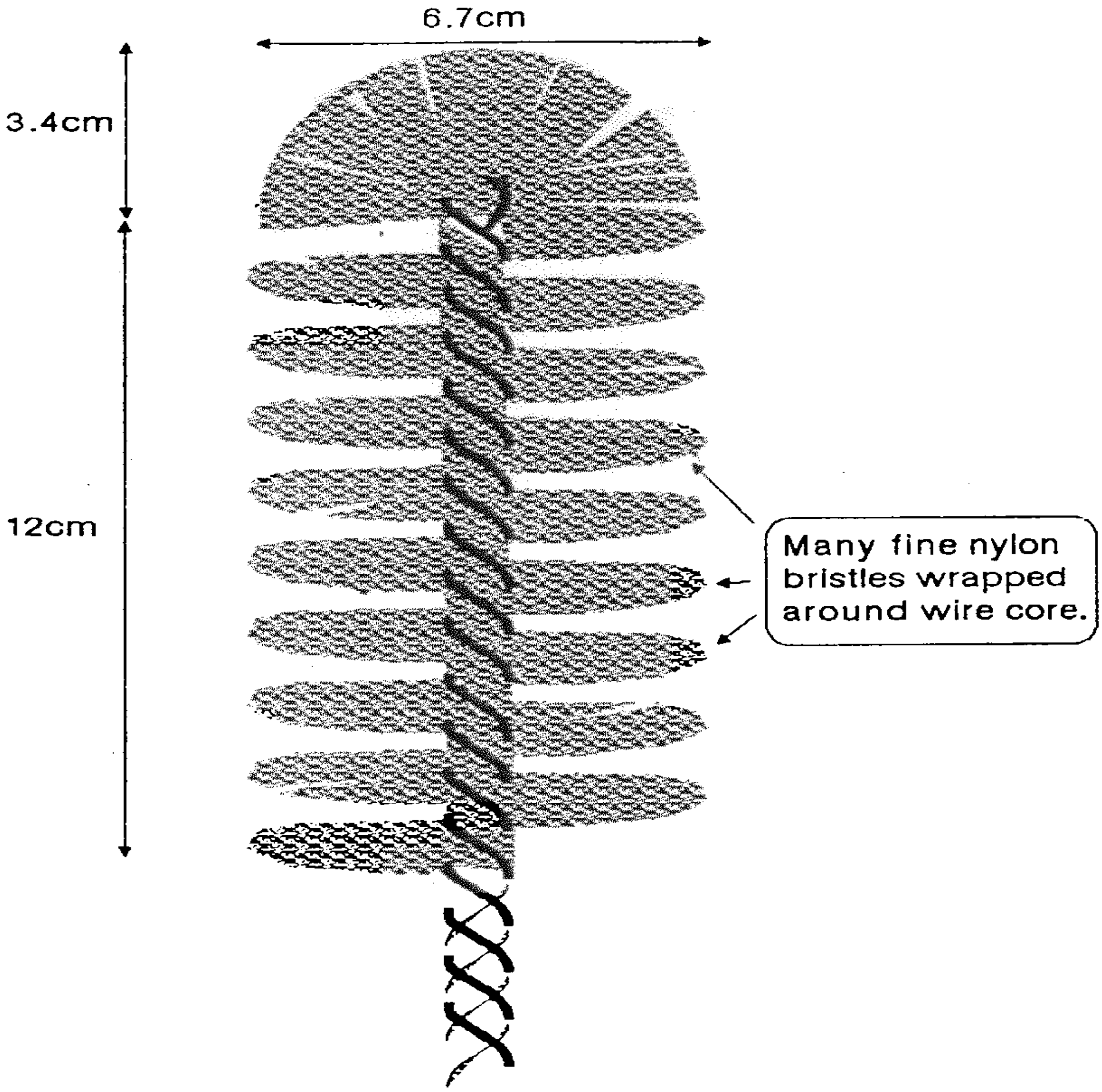


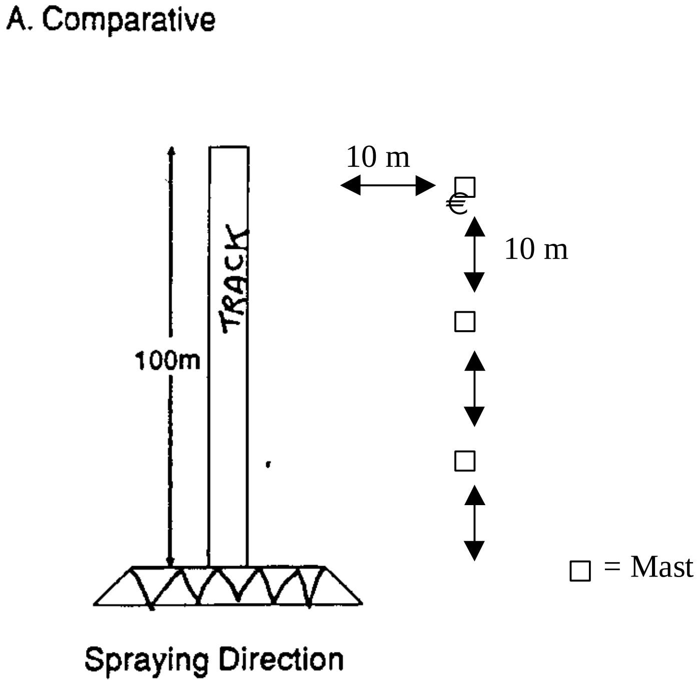
Figur 1: As the nozzle moves, so small drops are left floating behind

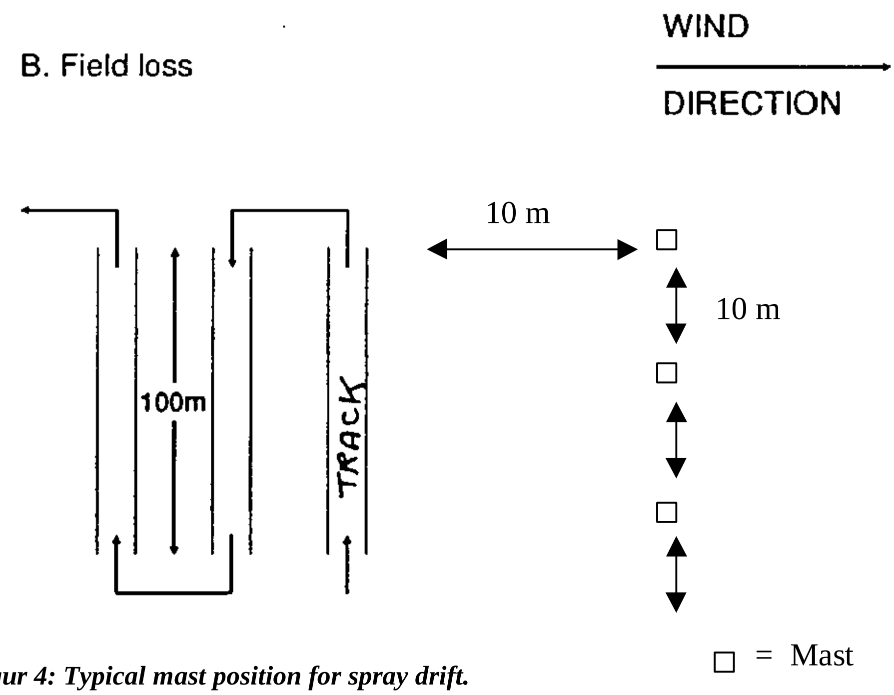


Figur 2: ***Hair curler - The curler is a cylindrical lattice with fine spikes protruding from the surface.***



Figur 3: Bottle brush





Figur 4: Typical mast position for spray drift.