An Attempt to Relate Drop Size to Drift Risk

W.A.Taylor, Research Coordinator, Hardi International A/S
A.R. Womac, Professor, University of Tennessee
P.C.H. Miller, Director of Technology, Silsoe Research Institute
B. P. Taylor, Independent Researcher, Taylands Research

Abstract

Near-field spray drift flux and fallout from U.S. ASAE reference nozzles was determined in the U.K. Silsoe Research Institute wind tunnel. Flux, or airborne drift, was measured downwind using ten horizontal monofilament collectors in a vertical plane [German DIX format], and fallout was measured with five horizontal monofilament collectors in a horizontal plane [U.K. LERAP format]. Tests were conducted using a fluorescent tracer, at tunnel wind speeds from 2-8 m/s, at boom heights of 500 and 1000 mm, and with a control nozzle to identify repeatability. Generally, LERAP lines under-measured near field drift compared to DIX lines, especially with increased boom height. Doubling the boom height increased airborne drift by a factor of three under some conditions. Results also indicated a strong non-linear increase in drift with decreased droplet size category threshold of Fine/Very Fine. Similar levels of drift were noted between thresholds Coarse/Very Coarse and Very Coarse/ Extremely Coarse. Droplet size, as determined by reference nozzle selection, was an important factor related to drift risk. However, use of the wind tunnel improved upon the prediction of drift risk as evidenced by the interaction effects of wind speed, boom height, and details of the nozzle spray emission such as porosity, angle and droplet velocity. Use of the wind tunnel as a tool should not be overlooked in future assessments of drift risk.

Introduction

The measurement of agricultural spray characteristics such as drop size, their numbers and velocities has led to a far greater understanding of the application requirements for pesticides; requirements that may need to be used to ensure optimal efficacy, crop selectivity or to avoid possible loss within and beyond the treatment zone. Currently, much interest is focussed on the need to reduce drift.

Techniques to measure drift include those based on field measurements and use of wind tunnels; methods currently being harmonised through international efforts to offer broad agreements on protocols to be adopted. Whilst field research is appropriate for obtaining realistic estimates of drift with sprayers under a range of working conditions such as cropping types, spraying speeds, buffer zone widths and windbreak vegetation, the controlled conditions of appropriate wind tunnel designs are well suited to permit repeatable relative studies of drift risk with single or low number arrays of nozzles.

Protocols that are used to measure drop size are now, almost, universally followed and the data that classifies sprays into Spray Qualities is extensively used by the whole industry. However, in the past, drop size [now spray quality] has been considered for the additional purpose of predicting drift (Southcombe et al., 1997). Regulators are keen to offer such drift risk advice on agrochemical trade labels and their influence has done much to encourage this move. The EU, for example, has introduced schemes to reduce pesticide fallout onto surface water and – with the introduction of recognised low drift equipment – offer farmers and growers the opportunity with some products to reduce buffer zone widths (Taylor et al., 1999). Similarly, the US EPA are looking towards the adoption of reduced drift techniques as a means to mitigate spray drift; EPA interests, however, being likely to include both airborne drift as well as near field fallout. Considerable care is needed in predicting the risk of drift from measurement of droplet size alone because drift is also a function of spray structure, velocities, and droplet structure. For this reason wind tunnel techniques have been developed to aid drift risk prediction.

The objective of this study was to establish improved relationships between sprays characterised by the ASAE S572 Standard (*ASAE Standards*, 50th Ed. 2003) with near field airborne and fallout drift under controlled conditions of a wind tunnel.

Materials and Methods

The tunnel and drift sampling methods

The selected wind tunnel, the Silsoe Research Institute (SRI) wind tunnel facility has been used extensively for the classification of nozzles within the UK's LERAP and – to a lesser extent – Germany's DIX schemes. Walklate et al. (2000) described the construction, design, performance and use of this purpose designed facility at SRI in UK for measuring near nozzle fallout drift whilst other researchers describe the UK LERAP scheme (Gilbert, 2000) and the basis for the selection of UK reference nozzles (Andersen et al, 2000). Similarly, Herbst and Ganzelmeier (2000) reported the use of a wind tunnel at BBA in Germany to predict airborne spray and how data is generated for the DIX scheme. Each protocol varies slightly in order to meet contrasting needs but have many shared principles. In both cases, single static nozzles are set to produce spray that is exposed to a wind with known characteristics such that the spray which is detrained is carried a short distance down the tunnel. The drifting cloud passes arrays of sampling lines that non-intrusively retain a representative sample of that cloud at that known location. However, the LERAP protocol positions collecting lines down the length of the tunnel to gain a direct measure of fallout whilst that for DIX uses a vertical array to quantify total volumes that may be lost downwind and predicts – from the volumes collected and 'shape' of the spray cloud – likely fallout.

Whilst LERAP collecting lines are likely to well predict fallout patterns, recent sampling technique studies (Taylor, 2004) suggested they may over sample that fraction of some cloud types being presented and, conversely, – wind tunnel length restrictions – could fail to consider that drifting fraction that has very low sedimentation velocities. The DIX vertical array, it is assumed, would better predict the total volume of drift that is available but the profiled drifting cloud data does not offer a direct fallout measure. Both approaches rely on subsequent computer modelling to estimate realistic fallout volumes that may result in the field from sprayers that have made several sequential swaths. Wind speeds used in the tunnel are selected to simulate the spraying speed of the sprayer; a technique that assess how much spray is detrained from the spraying plume but does not predict how that spray would then subsequently behave when exposed to ambient winds in the field.

The study herein assesses whether ASAE Spray Classifications can predict likely drift. DIX and LERAP collecting lines were used in order to offer the likely absolute quantities for available drift volumes and also predict the pattern of near field fallout out levels.

Experimental variables

Nozzle heights were based on those cited in nozzle manufacturers literature [500 mm] and what is more likely to be used [1000 mm] on large, fast sprayers in the US. Nozzle height was measured above the lowest collectors measuring horizontal drift fallout deposit. In addition, in order to simulate the range of spraying speeds at which arable spraying is likely to exploit, the static nozzles were exposed to wind tunnel airspeeds ranging from 2 to 8 m/sec and were positioned to represent a low boom height [500 mm] or one that is high [1000 mm]. It must be stressed that these winds speeds are used to reproduce spraying speeds; in other words, the induced wind speed that is presented to the spraying profile of the nozzle as it moves over the treatment area. In reality, drift generation is very different if there is a cross wind or if the sprayer is being directed into wind or with it. These reproduced conditions are not claimed to take these effects into account.

Nozzles

ASAE reference nozzles previously tested for droplet size (Womac, 2000) were used to establish their drift relating performance at those drop sized threshold levels that discriminate one category from another. These nozzles are all conventional flat fan types and do not have pre-orifice metering plates nor induce air. Thus, the larger drop size categories are generated at higher rates of spray liquid emission and narrower spray sheet angles. These sprays will have velocities greater than those from other nozzle designs, will produce a less wind porous spraying sheet and are now not so extensively used especially to apply lower water rates and large drop spraying. Nozzle details are shown in Table 1.

Table 1. Specifications and tolerances of reference nozzles for ASAE S-572.

Classification Category Threshold[1]	Nozzle Spray Angle (°)	Nominal Rated Flow Rate[2] (mL min^{-1})	Reference Flow Rate[3] (mL min^{-1})	Reference Operating Pressure[4] (kPa)
VF / F	110	380	480	450
F / M	110	1140	1180	300
M / C	110	2270	1930	200
C / VC	80	3030	2880	250
VC / XC	65	3780	3220	200

[1] VF - Very Fine
F - Fine
M - Medium
C - Coarse
VC - Very Coarse
XC - Extremely Coarse

[2] Nominal rated flow rate is at 276 kPa and is for nozzle size selection only.

[3] Reference flow rate is the actual rate used and has a tolerance of ± 40 mL min^{-1}. Reference flow rate was determined for this Standard from $Q=k\sqrt{P}$. The orifice coefficient (k) for each single, elliptical orifice reference nozzle is calculated from the nominally rated condition. The reference operating pressure (P) is listed in the above table. Tolerances for the reference operating pressure are described in the following footnote.

[4] Reference operating pressure is the hydraulic pressure used to obtain the reference flow rate and should be within a tolerance range of ± 3.4 kPa of the value tabled above. If the tolerance reference flow rate at the tolerance reference operating pressure can not simultaneously be achieved, a different nozzle should be selected.
All pressures are measured with a test gage with a minimum accuracy of 2 kPa. To minimize flow restrictions and potential pressure drop between the capillary and nozzle tip, test pressure is obtained via a capillary tube connected to a tee that accommodates the nozzle body. No nozzle strainer is present in the nozzle body.

It should be noted that the Teejet 6510 nozzle, supplied as part of the ASAE Reference set #3, was tested for output at the recommended 2 bars pressure and it was found to be necessary to adjust the pressure to 2.2 bars to obtain the desired output. Other test nozzles supplied were found to provide the desired output at the recommended pressure. Each reference nozzle corresponds directly with the nozzle identification numbers reported by Womac (2000) and have uniquely specified droplet factors (table 2).

Each nozzle was used individually in the tunnel and was supplied with water from a wheelbarrow sprayer through a pressure indicator and an electronically controlled supply switch. Having set the spray liquid supply system for the correct pressure, an electronically controlled exposure of 10 seconds spraying was used for all treatments; a time adequate enough to produce a measurable minimum deposit [with a sensitivity of +/- 0.05ul]. This time duration should not saturate the lines that have the greatest retained quantities nor risk loss through drips and run-off.

The magnitude of deposits recovered from the collecting lines, can vary for reasons attributable to the tunnel, analysis and/or operator skills, as well as changes in nozzle performance. It is, therefore, good practice to use a nozzle whose behaviour under these conditions is well documented and has indeed, been recorded on many occasions to monitor these possible sources of variability. A commercially representative ISO 03 [Hardi] nozzle was used at the start and finish of every group of treatments to monitor the tunnels performance and subsequent analytical methods used in this study against other relevant databases. The Hardi ISO 03 at 3 bars – producing a typical BCPC Medium spray quality – has traditionally been used for this ‘performance’ verification step – the only difference with other

Table 2. Droplet spectra factors for tested nozzles.

ASAE Tip (engraved i.d. #)	Droplet spectrum factor[1]		
	$D_{v0.1}$ (µm)	$D_{v0.5}$ (µm)	$D_{v0.9}$ (µm)
VF/F (#22)	45	107	180
F/M (#8)	68	163	341
M/C (#10)	90	244	477
C/VC (49)	106	365	681
VC/XC (22)	128	434	984

[1] Previously measured and reported by Womac (2000)

occasions is that water alone was sprayed in this work and not the more usual water with non-ionic surfactant at 0.1%.

Drift collector arrays

Two arrays were used – both using 1.98 mm diameter plastic tubes that were supported horizontally across the working width of the tunnel. DIX lines were in the vertical plane at 100 mm intervals some 2 metres from nozzle whilst the LERAP lines were positioned down the length of the tunnel 100 mm above its floor [500 or 1000 mm below the nozzle] at 1 metre intervals. The vertical collector array was extended from five horizontal lines to ten when the nozzles were used at the greater [1000 mm] height. "Airborne drift" refers to collections from vertical array (DIX) of collection lines, whereas "fallout" refers to collections from the horizontal (LERAP) array.

Spray solution

Tap water was used; a decision that was taken to avoid any interaction with formulation that may influence drop size and/or other spray features and to reproduce those conditions used when the nozzles are setting drop size threshold limits. *ASAE Standards*, 50th Ed. (2003) also specifies use of tap water to establish threshold boundaries for droplet classification categories. A fluorescent tracer (sodium fluorescein at 0.02%) was dissolved in the water to permit quantification of the drift deposits recovered from the collecting lines with a Perkin Elmer LS2 filter fluorimeter.

Data is shown as the volume of spray recovered from the lines or the total lost as airborne drift or as fallout. To make these calculations and charts, the collecting lines which were in the DIX vertical array and designated V10 [– at 1000 mm nozzle height] and V5 [– at 500 mm nozzle height] to V1 were used to gauge potential airborne loss whilst V1 to H6 in the horizontal LERAP array were used to gauge fallout. Line deposits were measured as ul of spray solution, converted to ul/litre emission and then to % of emission using the treatment mean line value – scaled up as if they sampled the whole area encompassed within each array of collectors.

Figure 1. Inside view of SRI wind tunnel, vertical plane of DIX collectors, and horizontal plane of LERAP collectors

Treatment list: Forty treatments were made in two days using the following nozzles, pressures and heights [distance of nozzle over lowest collecting lines]. The available time did not permit the use of finer sprays released at the greater height in faster wind speeds; treatments not included for they were considered to be obviously a very high drift risk and became, therefore, of a lower urgency in this first study (Table 3).

Table 3: The treatments applied in the SRI Wind Tunnel

Spray quality	**Run**	**Nozzle**	**Pressure; bars**	**Nozzle height; mm**	**Wind m/s**	**Flow rate l/min**
	1	Hardi ISO 03	3.0	500	2.0	1.193
VC/XC	2	Teejet 6510	2.2	500	2.0	3.173
	3	Teejet 6510	2.2	500	4.0	3.173
	4	Teejet 6510	2.2	500	6.0	3.173
	5	Teejet 6510	2.2	500	8.0	3.173
C/VC	6	Teejet 8008	2.5	500	2.0	2.799
	7	Teejet 8008	2.5	500	4.0	2.799
	8	Teejet 8008	2.5	500	6.0	2.799
	9	Teejet 8008	2.5	500	8.0	2.799
	10	Hardi ISO 03	3.0	500	2.0	1.193
	11	Hardi ISO 03	3.0	500	2.0	1.193
M/C	12	Lechler LU120-06S	2.0	500	2.0	1.927
	13	Lechler LU120-06S	2.0	500	4.0	1.927
	14	Lechler LU120-06S	2.0	500	6.0	1.927
	15	Lechler LU120-06S	2.0	500	8.0	1.927
F/M	16	Lurmark 31-03 F110	3.0	500	2.0	1.258
	17	Lurmark 31-03 F110	3.0	500	4.0	1.258
	18	Lurmark 31-03 F110	3.0	500	6.0	1.258
	19	Lurmark 31-03 F110	3.0	500	8.0	1.258
VF/F	20	Blank nozzle (A)	4.5	500	2.0	0.504
	21	Blank nozzle (A)	4.5	500	4.0	0.504
	22	Blank nozzle (A)	4.5	500	6.0	0.504
	23	Blank nozzle (A)	4.5	500	8.0	0.504
VC/XC	24	Teejet 6510	2.2	1000	2.0	3.173
	25	Teejet 6510	2.2	1000	4.0	3.173
	26	Teejet 6510	2.2	1000	6.0	3.173
	27	Teejet 6510	2.2	1000	8.0	3.173
	28	Hardi ISO 03	3.0	500	2.0	1.193
	29	Hardi ISO 03	3.0	500	2.0	1.193
C/VC	30	Teejet 8008	2.5	1000	2.0	2.799
	31	Teejet 8008	2.5	1000	4.0	2.799
	32	Teejet 8008	2.5	1000	6.0	2.799
	33	Teejet 8008	2.5	1000	8.0	2.799

M/C	34	Lechler LU120-06S	2.0	1000	2.0	1.927
	35	Lechler LU120-06S	2.0	1000	4.0	1.927
F/M	36	Lurmark 31-03 F110	3.0	1000	2.0	1.258
	37	Lurmark 31-03 F110	3.0	1000	4.0	1.258
VF/F	38	Blank nozzle (A)	4.5	1000	2.0	0.504
	39	Blank nozzle (A)	4.5	1000	4.0	0.504
	40	Hardi ISO 03	3.0	500	2.0	1.193

Results

Verification of tunnel and operational procedures

The variability between the start and finish of each day is plotted in Figure 2. The magnitude of variation was similar to previous tunnel experiments and was considered acceptable.

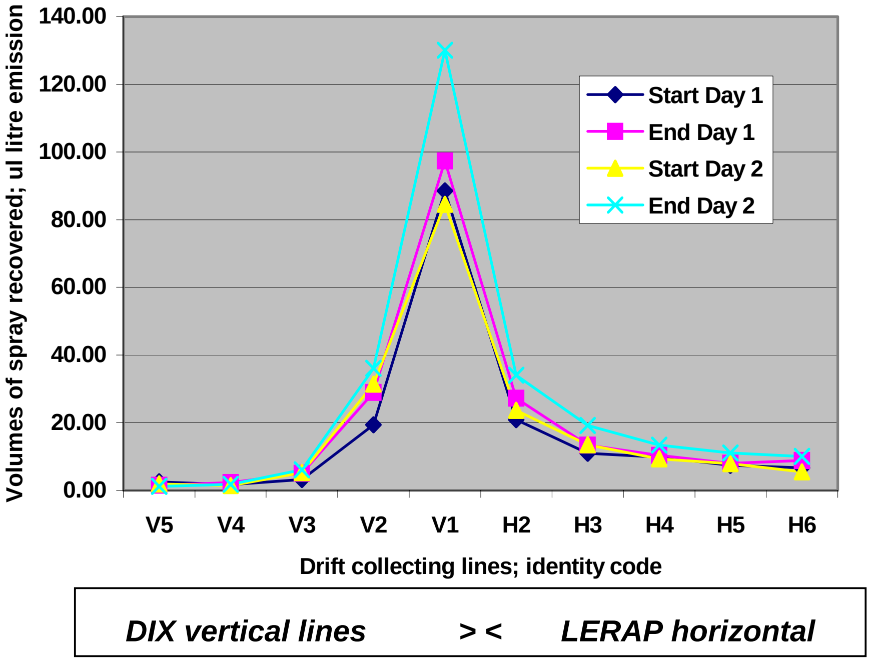

Figure 2. Standard nozzle (Hardi 03) performance in SRI Wind Tunnel, June 17-18 2004.

Mean airborne loss for this typical Medium spray was calculated from the vertical collector array as 0.54% of emission under these conditions of 2 m/sec wind. This value fits well the responses offered by the ASAE Reference nozzles (Figure 3) - the only possible discrepancy would be the suggestion that the ASAE M/C and/or F/M threshold nozzles generate more/less drift than that other values predict.

Airborne volumes and fallout from the ASAE reference nozzles

Airborne values, when sampled close to the nozzle at the point when fallout measurements also start, could be expected to be equal or greater than those calculated for the fallout. Indeed, at many points, both measures are equal. Where there is not agreement than the fallout volumes are always lower to suggest that – over the 6 metre sampling distance used down the tunnel – some fraction of the spray does not sediment to ground level. Finer sprays (Figure 4) and higher wind speeds (Figure 5) produced increased drift – and produced drops with lower sedimentation velocities – such that the magnitude of airborne loss is greater than that accounted for as near field fallout.

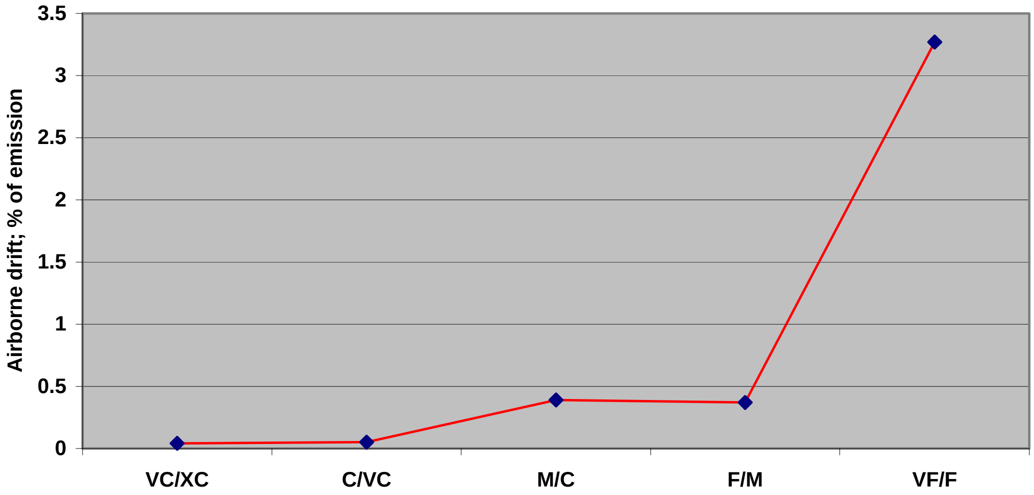

Figure 3. Finer sprays produced more airborne drift than coarse sprays in 2 m/sec airflow.

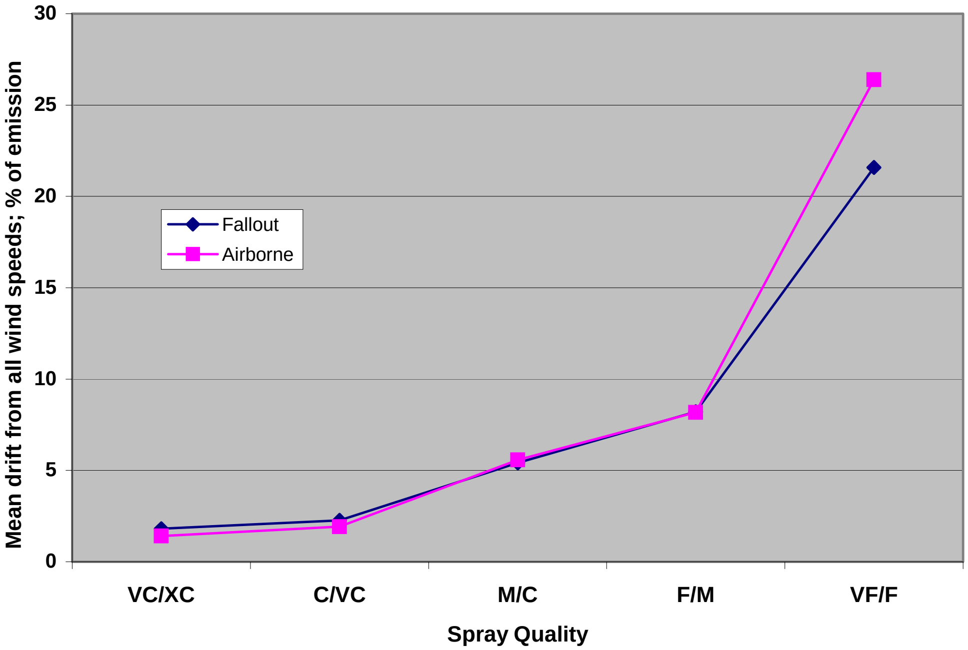

Figure 4. Airborne and fallout values from nozzles at 500 mm height are very similar. (Note: wind speeds [2 to 8 ms] are combined, nozzle was at 500 mm height.)

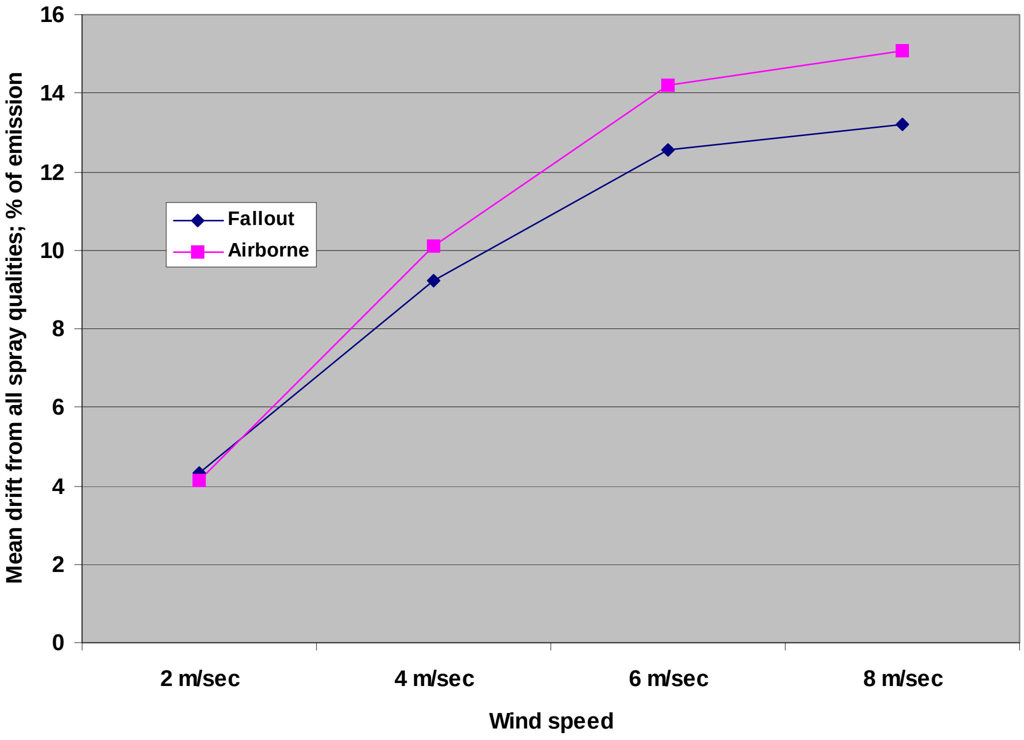

Figure 5. Airborne values increase over those for fallout in increasing wind speeds. (Note: Spray qualities are combined and nozzle was at 500 mm height.)

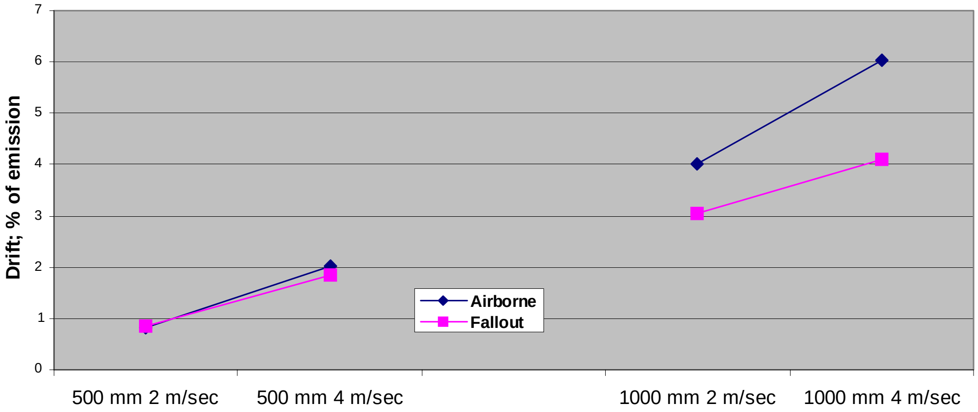

Figure 6. Mean volumes of airborne sprays from all spray qualities are comparable to those for fallout at 500 mm but not at nozzle heights of 1000 mm

This study – that used nozzles at both 500 and 1000 mm release heights – further verifies this potential scope for differences between the two sampling arrays if used in isolation to gauge total loss (Figure 6). The centre of the drifting cloud is raised at the greater release height and more of the drifting volume remains buoyant over the 6 m distance that the horizontal lines were located.

However, these observations may support concerns relating to these restraints but could also over simplify the true behaviour of using suspended thin sampling lines in horizontal arrays [as in the LERAP protocol]; lines that may over sample a low, buoyant cloud of laterally moving drops to give higher values than that which may fallout onto flat surfaces such as river or lake water (Taylor, 2004).

Hence, there may be a ‘trade off’ in the final measured drift value between the two sampling arrays that may influence how the subsequent experimental fallout data is interpreted.

DIX line arrays should generate total values for near field drift loss and can be used to show the characteristics of the drifting cloud. Irrespective of spray quality – faster wind speeds increase the magnitude of drifting volumes (Figures 7 and 8) but – there is a tenfold shift in these volumes for Very Coarse compared to those for Fine. The rate of increase with wind speed varies with spray quality and – under these conditions – there is an apparently rapid increase at 2 to 4 m/sec for all

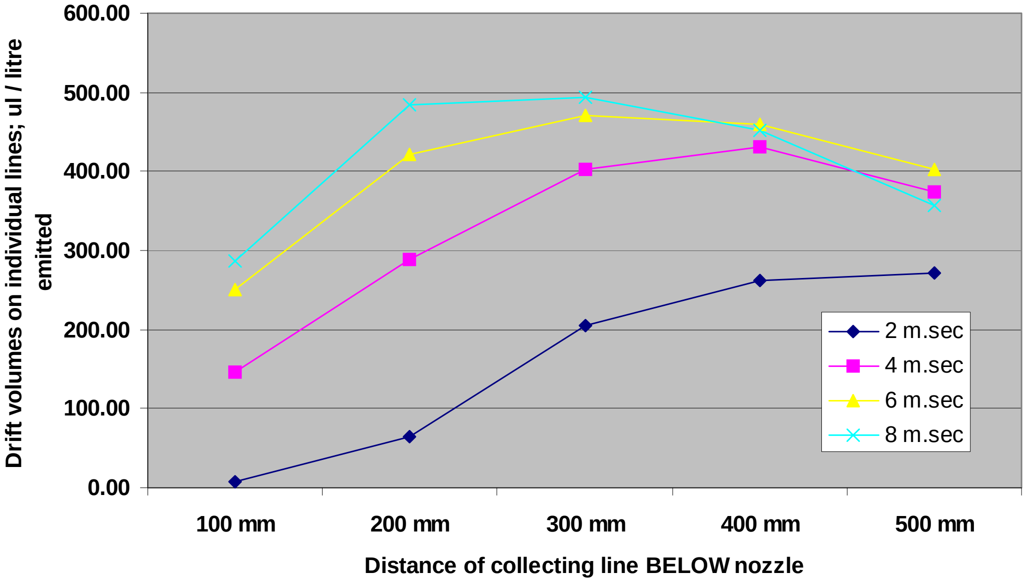

Figure 7. Airborne cloud profiles of Fine sprays change with wind speeds; drifting clouds are more intense and higher in 8 rather than in 2 m sec winds

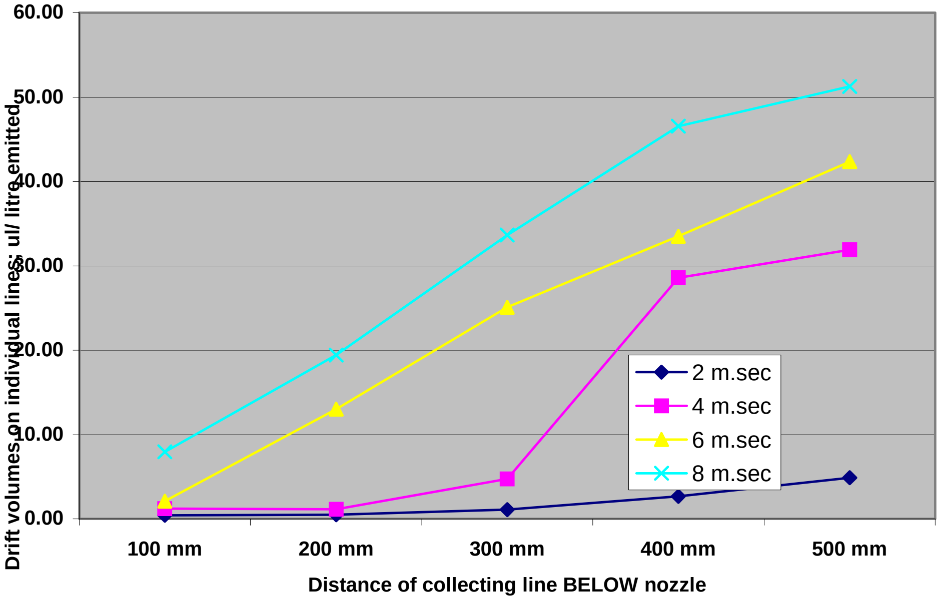

Figure 8. Very Coarse sprays produce low drifting clouds of low concentrations in wind speeds of 2 to 8 m/sec

spray qualities compared to 4 to 6 and 6 to 8 m/sec. It can also be observed that the centre for the moving drift cloud that is generated by Fine sprays is raised from the lowest sampled point [500 mm below the nozzle] in a 2 m/sec wind to 200 mm below the nozzle in a wind of 8 m/sec. The more intense centre of the cloud is closer to the nozzle [is moved at a greater height] in higher winds than in those that are lower. The low LERAP lines may not sample representative quantities of the drifting cloud.

Airborne drift clouds from Very Coarse sprays remain at a low height - irrespective of wind speed. Airborne volumes are better able to predict fallout quantities with such spray types. LERAP lines sample just the more intense section of the drifting cloud

Airborne and fallout losses are comparable from release heights of 500 mm (Figure 9 and 10). In both of these assessments of drift risk, there appears little difference between that volume for Extra Coarse and that for the smaller drop size of Very Coarse. At 6 to 8 m/sec there is an equal separation in the values for the Medium and Coarse spray qualities but not in other winds or drop sizes.

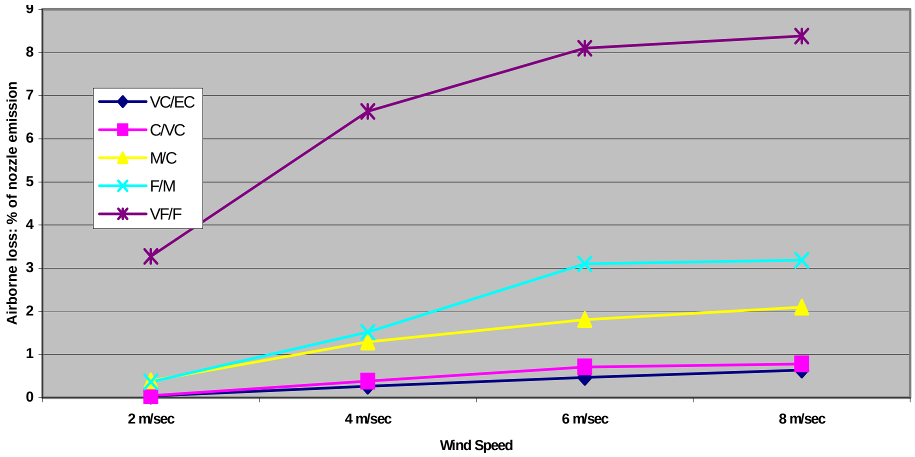

Figure 9. Airborne losses for all Spray Qualities emitted at 500 mm height appear to peak in wind speeds beyond 6 m/sec

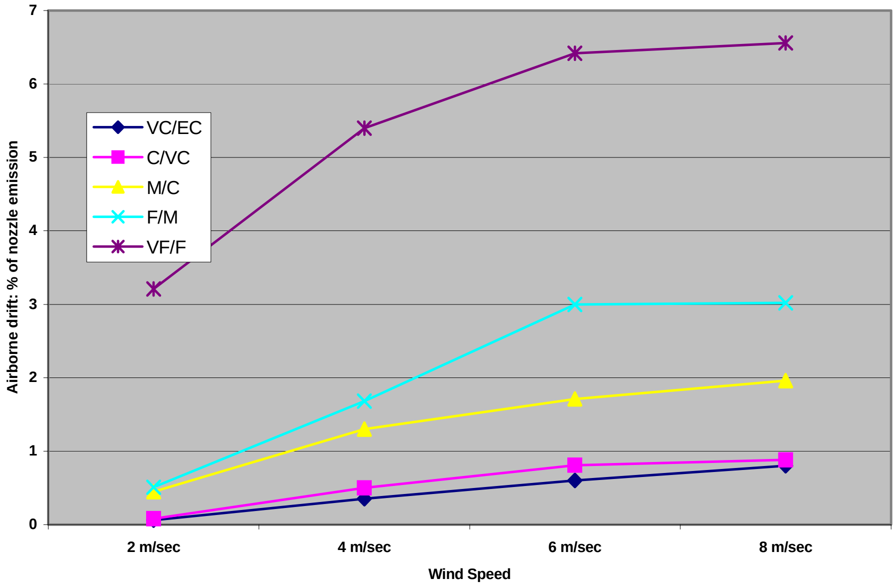

Figure 10. Fallout Losses for all Spray Qualities emitted at 500 mm height appear to peak in wind speeds beyond 6 m/sec

The VC/XC benefits in drift reduction may not contribute much more to safety than use of C/VC. At 6 and 8 m/sec wind, there is equal separation of the Medium and Coarse spray qualities - but not for Fine.

Boom height dominates at the lower wind speeds (Figure 11). Spray quality is still likely to remain one of the great influences of all variables measured. It appeared safer to use VC sprays at 1000 mm than Fine at 500 mm.

Raising wind speeds from 2 to 4 m/sec increased drift of Medium and larger spray qualities by a comparable amount to that gained when nozzles are raised from 500 mm to 1000 mm (Figure 12). Fine sprays released at 500 mm in 4 m/sec wind appeared to offer drift quantities that are little different to that at 1000 mm. One question is whether finer spray qualities dominate over release height - especially in higher 'wind' speeds?

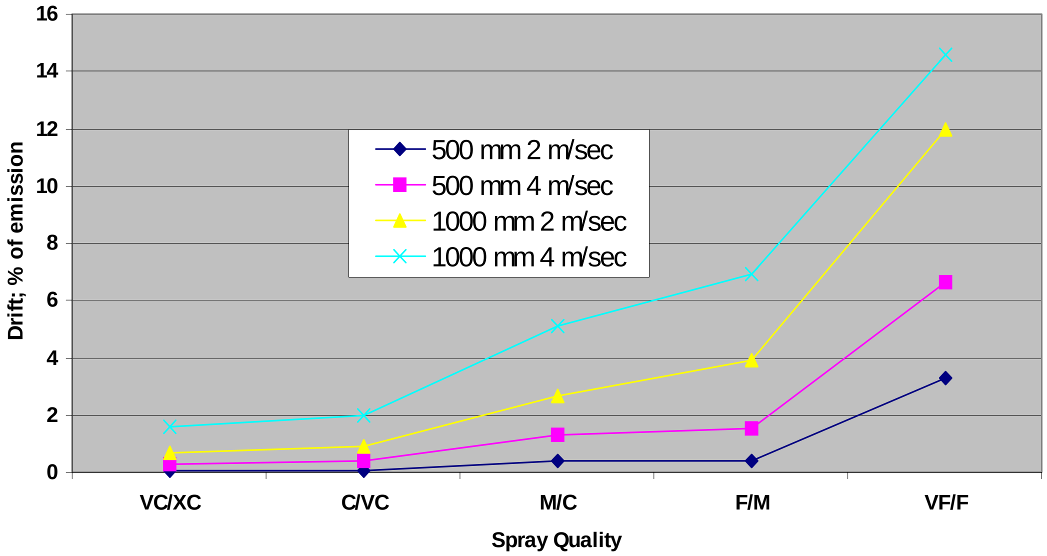

Figure 11. Nozzles at 1000 mm height produce more airborne drift than those at 500 mm in winds of either 2 m/sec or 4 m/sec

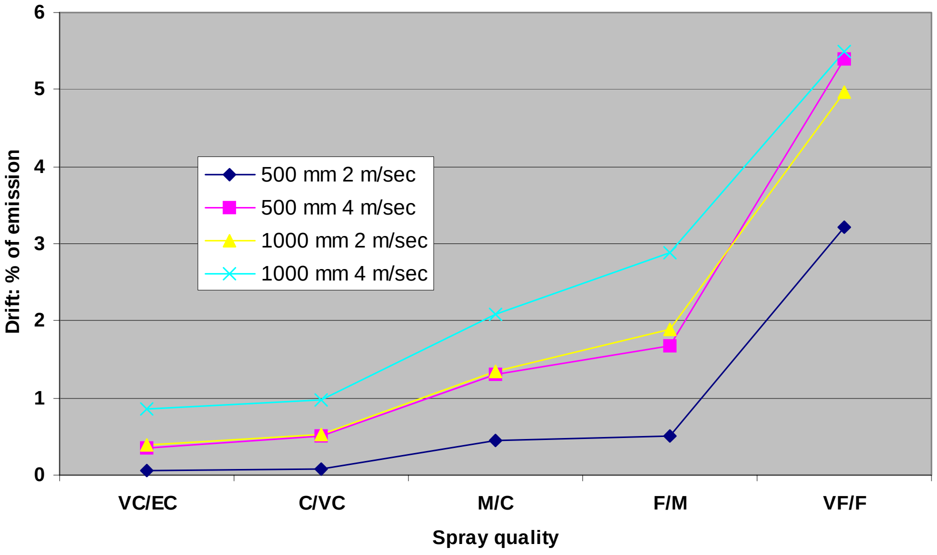

Figure 12. Nozzles at 1000 mm height produced a similar fallout in a 2 m/sec wind as nozzles at 500 mm in a 4 m/sec wind

Raising spray release height to 1000 mm from 500 mm, increases both airborne and fallout drift but the magnitude of such changes is still much influenced by use of smaller spray qualities, wind speeds and limitations of the extent of the [LERAP] sampling array Figure 13; latter observations being further restricted by the lack of data at 6 and 8 m.sec. Results – under these wind tunnel conditions – suggest that fallout volumes of Fine sprays are not increased when emission height is raised to suggest that a threshold quantity is reached that does not continue to worsen; a doubtful conclusion – but one that may reflect the detrainment characteristics of small droplets from Fine sprays. The use of a low turbulence approximately uniform airflow in the wind tunnel means that the form of the fallout curve in the tunnel is not expected to be the same as would be recorded under field conditions. Computer modelling techniques could predict one of these given the other.

Relating ASAE Spray Qualities to Airborne Drift Losses

We have noted earlier that the ASAE nozzles and/or their operational settings should be more accurately 'fine tuned' in the tunnel as a first step in future measurements. However, despite that limitation, there is the expected response between the reference series and measured airborne losses and cautious conclusions can be made.

Although not proven, it is believed that the DIX vertical array of collectors better predict total near field drift volumes rather than sedimentation volumes predicted by the LERAP lines alone. If this assumption is correct then Tables of airborne values can be generated for the ASAE nozzle reference set – spraying at two heights – which would enable comparisons to be made such that 'label writers' may or may not advise relative drift in a safe, clear manner. Using, for example, one arbitrary threshold drift loss of 3% - would under these conditions segregate higher drift risk nozzles/wind speeds from those that are safer (Table 4). Raising the height of spray release to 1000mm – and when using the same 3% limit – decreases the range of 'safe' spray qualities that may be used by, roughly, one spray quality (Table 5).

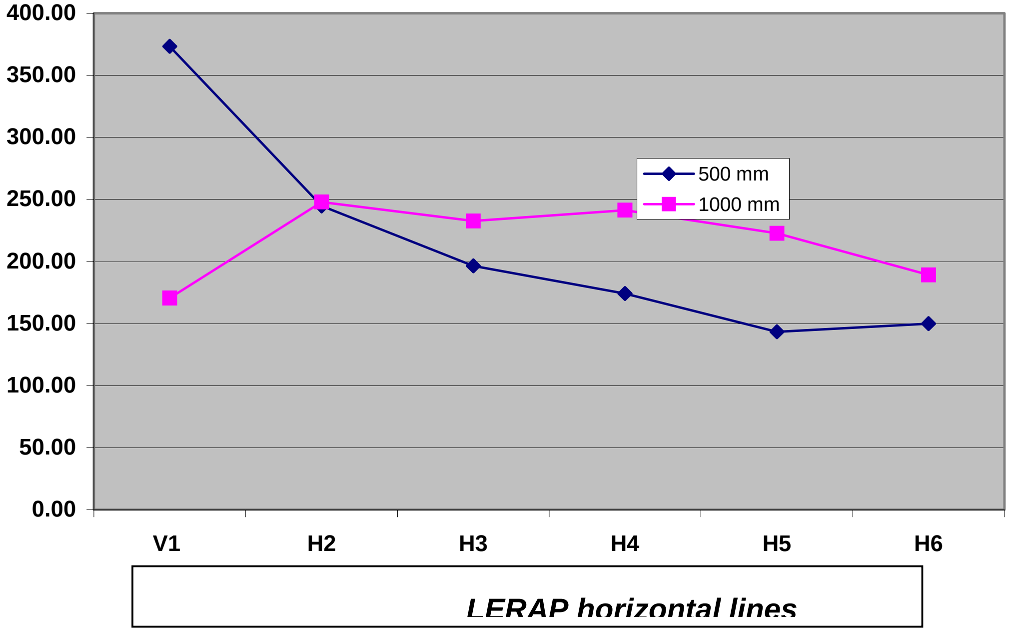

Figure 13. Fallout from Fine sprays at 1000 mm may not produce the expected decays with downwind distance in a 4 m/sec wind

Table 4. Airborne losses for the ASAE Reference nozzles at 500 mm height in wind speeds of 2 to 8 m/sec; % of nozzle emission

	Wind 2 m/s	4 m/s	6 m/s	8 m/s
VF/F	3.27	6.63	8.1	8.38
F/M	0.37	1.52	3.1	3.19
M/C	0.39	1.29	1.81	2.10
C/VC	0.05	0.38	0.71	0.78
VC/EC	0.04	0.27	0.47	0.64

Table 5. Airborne losses for the ASAE Reference nozzles at 1000 mm height in wind speeds of 2 to 8 m/sec; % of nozzle emission

	Wind 2 m/s	4 m/s	6 m/s	8 m/s
VF/F	11.96	14.57		
F/M	3.91	6.92		
M/C	2.65	5.09		
C/VC	0.88	2	2.68	2.83
VC/EC	0.67	1.58	1.95	2.25

It is assumed that data such as this would be the responsibility of the nozzle manufacturer and – after suitable verification – would be offered to the regulator for final scrutiny and acceptance.

Pesticide manufacturers, label writers and approvers have – in the past – avoided the use of numeric values for label 'advice'; preferring to use acceptable terms or symbols. In this instance, other bodies have used, for example, a * code. If this simpler approach was adopted in US then our Label writers would, it is assumed, propose words such as "Apply this product as a Medium quality spray having a Median to Low drift risk potential". In other words use a nozzle manufacturers rated drift mitigation performance of 3 to 5 *. Table 2 could be adapted as follows; the examples again using arbitrary threshold limits and not being levels proposed by the authors [Table 6].

Table 6. An attempt to grade drift risk with spray quality and spraying/wind speeds

	Wind 2 m/s	4 m/s	6 m/s	8 m/s
VF/F	*	NS	NS	NS
F/M	*****	***	*	*
M/C	*****	***	***	**
C/VC	*****	*****	*****	*****
VC/XC	*****	*****	*****	*****

Key	
<1%	*****
1-2%	****
2-3%	***
3-4%	**
3-5%	*
>5%	NS no star

Conclusions

Existing EU protocols that rate the drift risk of nozzles may be of value when assessing total quantities of near field drift for use in the US arable spraying context. In particular, the work identifies the limitations of using thin suspended lines for defining ***absolute*** drift losses. It is likely that more studies will be needed to modify these protocols for this precise purpose. Nonetheless, tentative conclusions can be made on whether ASAE spray quality measurements would or would not predict drift. Using airborne values, one can question whether the extra drift risk class – as defined by spray qualities of Extremely Coarse (XC)– offers any benefit in drift reduction between that already gained with Very Coarse.

Despite concerns with the methodology and reference nozzles used under the conditions described – there is clear trends that as droplet size is reduced so more drift results. Similarly, as spray release height increases so, too, drift levels rise. The authors have charted these differences and have shown how they may be simplified such that the operator can recognise low, median or high drift risk through spray quality and/or spraying speeds and/or nozzle heights. The relative magnitudes of these changes do follow predictions and, as such, encourage the need for further studies.

An important conclusion is that drift risk may be assessed by direct measurements in wind tunnel conditions conducted to an appropriate protocol rather than based solely on measurements of droplet size distributions. Modelling techniques will enable results to be extrapolated from the "ideal" wind tunnel situation to typical field conditions.

References

Andersen, P.G., W.A. Taylor, I. Lund and P.C.H. Miller. 2000. A wind tunnel protocol used to generate drift and fallout data; an appraisal. *Aspects of Applied Biology* 57: 121-130.

ASAE Standards, *50th Ed. 2003. S572 Aug99 Spray nozzle classification by droplet spectra. St. Joseph, Mich.: ASAE* .

Gilbert, A.J. 2000. Local Environmental Risk Assessment for Pesticides (LERAP) in the UK. *Aspects of Applied Biology* 57:83-90.

Herbst, A. and H. Ganzelmeier. 2000. Classification pf sprayers according to drift risk – a German approach. *Aspects of Applied Biology* 57:35-40.

Southcombe, E.S.E., P.C.H. Miller, H. Ganzelmeier, J.C. Van de Zande, A. Miralles, and A.J. Hewitt. 1997. The international (BCPC) spray classification systemincluding a drift potential factor. 1997 BCPC Weeds pp 371-380.

Taylor, B.P. 2004. Some performance aspects of downwind fallout collection targets used in the assessment of Low Drift Equipment and their potential to predict absolute ground based deposits *Aspects of Applied Biology* 71:431-440.

Taylor, W.A., S.E. Cooper, and P.C.H. Miller. 1999. An appraisal of nozzles and sprayer abilities to meet regulatory demands for reduced airborne drift and downwind fallout from arable crop spraying. 1999 BCPC Weeds pp 447-452.

Walklate, P.J., P.C. Miller and A.J. Gilbert. 2000. Drift classification of boom sprayers based on single nozzle measurements in a wind tunnel. *Aspects of Applied Biology* 57:49-56.

Womac, A.R. 2000. Quality control of standardized reference spray nozzles. *Transactions of the ASAE* 43(1):47-56.