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Special Issue: Spray Drift Reduction

Research Paper

Wind tunnel measurements and model predictions for estimating spray drift reduction under field conditions

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A UK scheme to enable the protection of surface water from spray drift allows farmers to reduce the size of a buffer zone according to the drift-reducing capability of the sprayer. Recent changes to UK regulations have allowed buffer zones greater than 6 m to be included, providing that 75% drift reduction conditions are used. However, there is an implicit assumption that the level of drift reduction is independent of distance downwind, so that measurements relating to a 6 m buffer zone can be applied to 20 m.

An investigation of the relationship between wind tunnel and field data was carried out with the purpose of establishing if drift reduction measured between 2 and 7 m in the Silsoe wind tunnel can be extrapolated to 20 m in the field. A computer-based spray drift model was used to explore some of the factors influencing downwind spray drift to support this extrapolation.

It was concluded that spray drift reduction is dependent on distance downwind, but that wind tunnel measurements can be used to estimate this at least up to 20 m downwind. Improvements to the wind tunnel protocol were identified, which will need to take account of how the data will be used in the regulatory process before implementing. Further discussions are needed to harmonise methods for determining spray drift reduction across EU member states, but this approach of mapping the wind tunnel data onto field data is one that should be possible with other methods.

Abbreviations: CSL, Central Science Laboratory; Fera, The Food and Environment Research Agency; LERAP, Local Environment Risk Assessment for Pesticides; DIX, Drift Potential Index.

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Nomenclature

α	rate at which drift deposits decline with distance, dimensionless
α_{test}	rate at which deposits decline for test conditions, dimensionless
α_{ref}	rate at which deposits decline for reference conditions, dimensionless
A	magnitude of the drift at 1 m downwind, arbitrary units
A_{test}	magnitude of the drift at 1 m downwind for test conditions, arbitrary units
A_{ref}	magnitude of the drift at 1 m downwind for reference conditions, arbitrary units
d	ground deposits of drift, arbitrary units
$D5_{test}$	Value of d at around 5 m downwind for test values
$D5_{ref}$	Value of d at around 5 m downwind for reference values
x	distance downwind

1. Introduction

A scheme for protecting surface water from spray drift was introduced into the UK in 1999. Known as the Local Environmental Risk Assessment for Pesticides (LERAP) it has operated successfully for a number of years, introducing a 6 m buffer zone and allowing farmers to reduce the size of a buffer zone according to the drift-reducing capability of the spraying equipment (Defra, 2001) for some categories of pesticides. The potential of equipment to reduce spray drift, relative to a reference condition, is denoted by a 'one, two or three star rating' and these ratings can be determined from either field or wind tunnel drift data. The wind tunnel reference condition is defined as a commercially-available standard flat fan nozzle, 110° fan angle (current reference nozzles are F110-03 nozzles, Hypro EU Ltd. Longstanton, Cambridge, United Kingdom), operating at 300 kPa fluid pressure at a height of 0.5 m above the spray drift collectors. The field reference condition is the same, but the nozzles are mounted on a 12 m boom sprayer operating at 8 km h^{-1} over a short crop or bare ground (Gilbert, 2000). The majority of LERAP star ratings that has been claimed to date is based on wind tunnel assessments, largely because the smaller scale and controlled conditions allow the necessary data to be obtained in the most cost-effective and timely manner.

Recent changes to UK regulations relating to spray drift have allowed buffer zones greater than 6 m to be included, provided that three-star-rated application conditions (i.e. 75% drift reduction) are used (Chemicals Regulation Directorate, 2014). There is an implicit assumption in this development that the level of drift reduction is independent of distance downwind, so that measurements relating to a 6 m buffer zone can be applied to 20 m. It is important to establish whether or not this is the case.

Wind tunnel data relevant to the original LERAP scheme have been compared with limited field data (Walklate, Miller, & Gilbert, 2000). It showed that drift reduction measured in the wind tunnel is comparable with drift reduction in the field. There would be benefits from extending this comparison to a wider range of field data in order to demonstrate more robustly that the drift reduction determined from wind tunnel experiments can be mapped onto drift reduction in full-scale field conditions, and to identify the range of circumstances, particularly distances downwind, for which this drift reduction applies. It would also be beneficial to assess whether modifications to the LERAP star rating protocol – either the measurement or subsequent analysis – would improve the correlation between wind tunnel and field data for a wider range of conditions.

This paper reports an investigation of the relationship between wind tunnel and field data, based on existing field data, and new measurements of spray drift in the Silsoe wind tunnel. A computer-based drift model is used to explore some of the factors influencing the downwind drift profile and to support the extrapolation between wind tunnel and field. The objectives of the study were to:

(a) Determine the extent to which drift reduction measured in the wind tunnel is equivalent to drift reduction in the field, and particularly if it can be extrapolated to distances up to 20 m;
(b) Identify any possible improvements in the protocols for wind tunnel measurements and data analysis
(c) Explore options for harmonising the different European schemes for determining drift reduction.

2. Theoretical analysis of drift curves

The current LERAP star rating system relates to 25, 50 and 75% drift reduction compared with the reference spray application determined from data obtained between 2 and 7 m downwind and using 6 m as a reference distance. In order to extend the system to buffer zones greater than 6 m, it is possible that changes to the calculation are required.

A number of researchers have proposed that the relationship between sedimenting drift (i.e. ground deposits) and distance downwind follows a power law decay (e.g. Walklate et al., 2000; De Schampheleire, Baetens, Nuyttens, & Spanoghe, 2008), i.e.

$$d = Ax^{-\alpha} \quad (1)$$

where d is ground deposits of drift (arbitrary units), A defines the magnitude of the drift at 1 m downwind, x is the distance downwind and α defines the rate at which drift deposits decline with distance. Zero distance is taken as the centre line of the last downwind nozzle for our analysis.

This equation is valid only for x > 0, and other equations might give a better fit, particularly close to the treated area – for example Holterman and van de Zande (2003) use two exponential curves and Nuyttens, De Schampheleire, Baetens, and Sonck (2007) use a single exponential equation. Continuing to use a simple power law has many advantages, however, since it is relatively easy to compare curves, and also there are only two unknowns for any drift curve, so curves can be fitted with relatively few data points.

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