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Special Issue: Spray Drift Reduction

Research Paper

Field-crop-sprayer potential drift measured using test bench: Effects of boom height and nozzle type

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Because of variations in environmental conditions, spray-drift field measurements following ISO 22866:2005 involve complicated and time-consuming experiments often with low repeatability. Therefore, simple, repeatable, and precise alternative drift assessment methods that are complementary to the official standards are required. One of the alternatives is the use of a drift test bench for field crop sprayers. Previous studies have demonstrated that the drift test bench can be considered an adequate complement to existing standard protocols for field drift measurements. In this study, in order to further improve the methodology and to evaluate the possibility of classifying different field-crop-sprayer settings according to drift risk using a test bench, a series of tests were performed in a test hall. A conventional mounted Delvano HD3 crop sprayer (Delvano, Kuurne, Belgium) equipped with an 800-l spray tank and a 15-m-wide stainless steel spray boom was used. Eight different sprayer setups were tested, involving three nozzle types (TeeJet XR 110 04, Agrotop TDXL 110 04 and Micron Micromax 3) and three boom heights (0.30, 0.50, and 0.70 m). For the drift classification, the reference sprayer drift behaviour was defined as that obtained using conventional flat fan TeeJet XR 110 04 nozzles operated at 0.30 MPa and at a boom height of 0.50 m. The different sprayer setups were successfully assigned to different drift reduction classes, and the results underlined the effects of nozzle type and boom height on the potential drift. The feasibility of the test-bench methodology for classifying field-crop-sprayer drift according to ISO 22369-1:2006 was demonstrated.

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Nomenclature

D	spray deposit measured on Petri dish (µl cm^{-2})
As	absorbance (ABS, dimensionless) of Petri dish sample washing
A_0	absorbance (ABS, dimensionless) of blank Petri dish sample washing
At	absorbance (ABS, dimensionless) of tank solution
V	volume of deionised water (µl) used to elute sample
S	area of Petri dish collection surface (165 cm^2)
DPV	drift potential value (dimensionless)
Di	spray deposit on single deposit collector placed in covered bench slots (µl cm^{-2})
D[v,0.1]	Droplet size parameter. 10th percentile
D[v,0.5]	Droplet size parameter. 50th percentile
D[v,0.9]	Droplet size parameter. 90th percentile
RSD	reference spray deposit under boom (µl cm^{-2})
SE	standard error of the mean
VMD	Volume Median Diameter

1. Introduction

The requirements of the European Directive 128/2009/EC on the sustainable use of pesticides include the objective to reduce spray drift during application of agrochemicals to crops, especially in the proximity of sensitive areas (e.g., water bodies, natural reserves, and urban areas). To achieve this goal, various spray-drift mitigation measures can be adopted, which either affect the sprayer components directly (e.g., the mounting of air-induction nozzles) or require sprayer adjustment. Alternatively, indirect mitigation measures such as the construction of buffer zones and physical barriers (e.g., hedges) along the borders of sprayed fields can be adopted. A combination of direct and indirect spray-drift mitigation measures may facilitate minimisation of the widths of the buffer zones established between the application areas and the sensitive zones, thereby increasing the land surface available for cultivation.

In order to define buffer-zone widths, it is necessary to consider certain parameters, such as the features of the sensitive area in question (e.g., the size of a water course), the toxicity of the applied agrochemicals and, most importantly, the spray application parameters adopted for the agrochemical distribution (Gilbert, 2000; Nilsson & Svensson, 2004). As regards the latter, it is necessary to consider the sprayer type, nozzles, and operative parameters of the sprayer (Herbst & Ganzelmeier, 2000; Nuyttens, De Schampheleire, Baetens, & Sonck, 2007; van de Zande, Porskamp, Michielsen, Holterman, & Huijsmans, 2000). In 2006, criteria to classify spraying equipment according to drift risk were established (ISO 22369-1:2006). These criteria are based on a relative comparison between the drift generated by the candidate spraying equipment and a reference apparatus, which is selected as being representative of the most common spraying technique adopted for a certain scenario (e.g., for application to field crops, vineyards or orchards). To date, this relative comparison has been performed using drift measurement data that can be obtained in the field, applying the ISO 22866:2005 test methodology (ISO 22866:2005), or in a laboratory wind tunnel, following the ISO standard 22856:2008 (Nuyttens et al., 2011).

Both standardised test methodologies, however, have certain limitations. ISO 22866:2005 methodologies are designed for tests to measure the amount of drift outside the applied field for defined wind-speed and -direction conditions. However, it is difficult to perform relative comparisons between spraying results, as operation under the same wind conditions is required for a successful comparison. Moreover, the test procedure itself is complex and time consuming and, as regards spray application to arboreal crops, the results are affected by the morphological and vegetative features of the orchard/vineyard in which the tests are performed. On the other hand, the ISO 22856:2008 methodology facilitates the performance of relative comparisons more rapidly. However, this comparison is primarily between nozzles rather than the full spraying system, as the test procedure involves drift measurement in a wind tunnel with dimensions sufficient to contain small boom sprayers only. Therefore, using ISO 22856:2008, it is difficult to compare the spray drift generated by complete sprayers, since drift not only depends on the spray quality, but also on the sprayer configuration and adjustment.

To overcome these limitations, researchers at the Dipartimento di Scienze Agrarie, Forestali e Alimentari (DiSAFA) at the University of Torino (Turin, Italy), in collaboration with the Advanced Agricultural Measurement Systems (AAMS)-Salvarani company (Maldegerm, Belgium), researched and developed an *ad hoc* test bench for the measurement of potential spray drift (Balsari, Marucco, & Tamagnone, 2007). Potential spray drift is defined as the percentage of initial spray volume that remains suspended in the air after the sprayer passage and which represents the fraction of spray liquid more susceptible to drift out of the treated area by the action of air currents during the application process. It differs from the absolute spray drift because it consists only of a plume of droplets which remain suspended in the air after the passage of the sprayer along the swath and these droplets deposit sometime after the boom has moved over a given point. As potential drift has to be measured in the absence of wind, its amount is not affected by wind velocity and direction, but it depends only on the turbulence generated by the sprayer moving forward and is influenced by boom height and size of the sprayed droplets. On the other hand absolute spray drift, according to the definition given in ISO 22866 (2005) is represented by the "quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process". Its amount is therefore represented by all the spray that is applied within the field but is blown out of target area by wind. Wind velocity and direction therefore strongly affect absolute drift values, making it difficult to determine the influence of individual sprayer parameters on the results obtained, particularly if the wind conditions vary. This is the reason why, in order to make relative comparisons between spraying equipment in terms of drift risk, measurement of potential drift was considered here to be a more suitable parameter for providing objective and

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