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Field experiment on spray drift: Deposition and airborne drift during application to a winter wheat crop

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ABSTRACT

A field experiment was performed to evaluate various techniques for measuring spray deposition and airborne drift during spray application to a winter wheat crop. The application of a spraying agent containing the fluorescent dye Brilliant Sulfo Flavine by a conventional boom sprayer was done according to good agricultural practice. Deposition was measured by horizontal collectors in various arrangements in and outside the treated area. Airborne spray drift was measured both with a passive and an active air collecting system. Spray deposits on top of the treated canopy ranged between 68 and 71% of the applied dose and showed only small differences for various arrangements of the collectors. Furthermore, only small variations were measured within the various groups of collectors used for these arrangements. Generally, the highest spray deposition outside the treated area was measured close to the sprayed plot and was accompanied by a high variability of values, while a rapid decline of deposits was detected in more remote areas. Estimations of spray deposits with the IMAG Drift Calculator were in accordance with experimental findings only for areas located at a distance of 0.5–4.5 m from the last nozzle, while there was an overestimation of a factor of 4 at a distance of 2.0–3.0 m, thus revealing a high level of uncertainty of the estimation of deposition for short distances. Airborne spray drift measured by passive and active air collecting systems was approximately at the same level, when taking into consideration the collector efficiency of the woven nylon wire used as sampling material for the passive collecting system. The maximum value of total airborne spray drift for both spray applications (0.79% of the applied dose) was determined by the active collecting system. However, the comparatively high variability of measurements at various heights above the soil by active and passive collecting systems revealed need for further studies to elucidate the spatial pattern of airborne spray drift.

1. Introduction

Doubling in global food demand projected for the next 50 years poses huge challenges for the sustainability both of food production of ecosystems and the services they provide to society (Tilman et al., 2002). Agricultural practices determine the level of food production and, to a great extent, the state of the global environment. Main environmental impacts of agriculture come from agricultural nutrients that pollute aquatic and terrestrial habitats, and from pesticides, especially bioaccumulating or having the potential for movement from the site of application. Off-target drift during pesticide

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application is known to be an important source of pesticide contamination in the atmosphere and is mainly affected by application methods, formulation, environmental conditions and spray-cloud processes (Majewski and Capel, 1995). In contrast to other loss pathways of pesticides, e.g. volatilization from soil and plant surfaces (Siebers et al., 2003; Wolters et al., 2003, 2004), spray drift losses are independent from the pesticide properties but dependent on the formulation used (Reichenberger et al., 2007). During the last years several approaches for the assessment of spray drift using conventional field sprayers have been developed, which reflect the processes affecting spray drift with varying degrees of accuracy (e.g., Brusselman et al., 2003; Holterman et al., 1997; Kaul et al., 1996, 2001). An overview of methods and mathematical procedures to assess and model spray drift was presented by Gil and Sinfort (2005). Due to these models being still in an early stage of development and hardly validated, the reliability of their predictions does currently not allow their use for evaluation and registration purposes. Instead, the European Union approval of pesticides carried out under the terms of the Authorizations Directive (Council Directive 91/414/EEC, 1991) requires data on spray drift to adjacent watercourses for various techniques and crops (Ganzelmeier et al., 1995; Rautmann et al., 2001) to be used for the estimation of spray drift during application. Current regulatory procedures for risk assessment are based on standard parameters included in a Drift Calculator (Holterman and Van de Zande, 2003), a utility that combines drift data gathered in various studies to calculate the amount of pesticide deposits on surface waters. These simulations were obtained using standard scenarios, and thus field studies in more realistic conditions are required to refine risk assessment (Vischetti et al., 2008; Linders et al., 2001).

Although it has been shown that field-scale drift measurements (e.g., Ravier et al., 2005) may be useful as input for realistic modeling and for calculation of the potential exposure to surface water (Padovani and Capri, 2005), the lack of comparability in methodology such as the measurement of spray drift, makes it difficult to compare the results of various studies (Meli et al., 2003). This situation is even more complicated by the fact that highly variable drift values were due to fluctuating wind speed and direction (Padovani and Capri, 2005). For reasons of data exchangeability and comparison recently an international standard for the measurement of spray drift has been published (ISO 22866).

Various methods by which spray drift can be measured are available. Two of the most important drift sampling techniques are based on ground sedimentation of droplets onto horizontal surfaces and airborne concentrations measured at defined points downwind of an application site (e.g., Van de Zande et al., 2000). Data gathered by droplet sedimentation measurement is mainly used in risk assessments, especially to protect surface water, and has led to the adoption of buffer zones between the treated field and water ways. Airborne concentration measurements of droplets drifting downwind of an application area are relevant to risk assessments relating, for example, to bystander inhalation (Miller, 2003).

It was thus the goal of this work to apply and evaluate various techniques for measuring spray deposition and airborne drift during spray application to a winter wheat crop. Measurements were carried out by adding the fluorescent dye Brilliant Sulfo Flavine (BSF) to the spray agent and subsequent application using a conventional boom sprayer. Spray deposition was measured by placing horizontal collectors in various arrangements in and outside the treated area. Airborne spray drift was measured both with a passive and an active sampling system. In the second stage, experimental findings on spray deposition were compared to the output of the Drift Calculator.

2. Material and methods

2.1. Field site, application and environmental conditions

The experiment was performed on a rectangular winter wheat field divided into two field plots near Jülich-Merzenhausen,

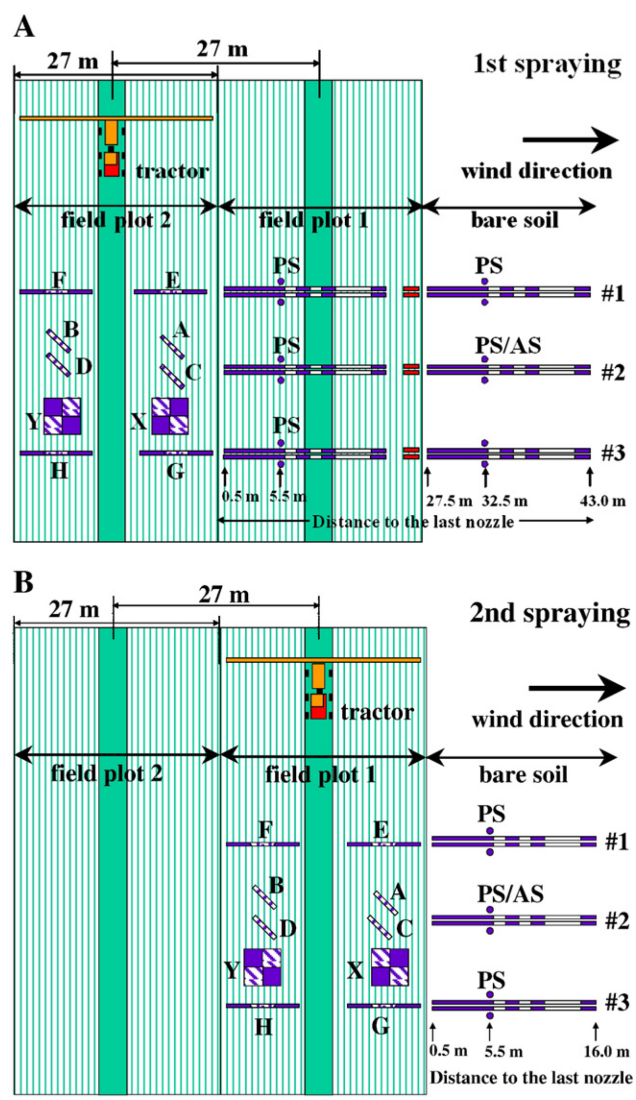

Fig. 1 – Field site and arrangement of collectors on the treated and untreated area. A: 1st spraying on field plot 2. B: 2nd spraying on field plot 1. A–D: Collectors diagonal to driving direction. E–H: Collectors arranged in an array cross to the driving direction. X–Y: Collectors arranged in a square meter parallel to the driving direction. AS: Active sampling. PS: Passive sampling.