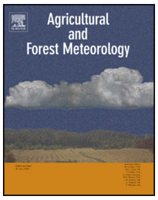
Agricultural and Forest Meteorology 202 (2015) 94–101

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet



Influence of wind velocity and wind direction on measurements of spray drift potential of boom sprayers using drift test bench

Emilio Gil[a,*], Montserrat Gallart[a], Paolo Balsari[b], Paolo Marucco[b], Mª Pilar Almajano[c], Jordi Llop[a]

[a] *Universitat Politècnica de Catalunya, Department of Agro Food Engineering and Biotechnology, Esteve Terradas, 8, 08860 Castelldefels, Spain*
[b] *Università di Torino, DISAFA, Largo Paolo Braccini, 2, 10095 Grugliasco, Italy*
[c] *Universitat Politècnica de Catalunya, Chemical Engineering Department, Av. Diagonal 647, 08028 Barcelona, Spain*

ARTICLE INFO

Article history:
Received 11 April 2014
Received in revised form
24 November 2014
Accepted 3 December 2014
Available online 27 December 2014

Keywords:
Drift potential value (DPV)
Drift test bench
Wind velocity
Wind direction
Spray deposition
Spray drift

ABSTRACT

In 2009, the European Directive for a Sustainable Use of Pesticides (128/2009/CE) established important mandatory actions to be accomplished by all Member States (MS) in the European Union. The main objective is to achieve the sustainable use of pesticides by reducing their risks and impacts on human health and the environment. Among other important actions, drift reduction measures are essential to avoid the entry of plant protection products (PPP) in water or other undesirable areas. As the risk of environmental contamination is directly related to the spray application technology, there is a strong need for objective methods for drift evaluation as well as robust procedures for the classification of sprayers according to their risk of contamination. For this purpose, and as a complementary tool to actual drift measurement methodologies in the field or in laboratory conditions, a new method has been proposed for the quantification of the potential drift generated by horizontal boom sprayer systems using an ad hoc test bench.

This study aims to evaluate the influence of wind velocity and wind direction on the drift potential value (DPV) using the proposed methodology and test bench. The results indicated that wind velocities below 1.0 m s^{-1} have a negligible influence on the DPV. Front wind led to higher DPVs than lateral wind. A global analysis of data indicates that the proposed methodology and test bench are interesting tools for the quick and objective evaluation of the potential drift if used in appropriate environmental conditions.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

The European Directive for a Sustainable Use of Pesticides (128/2009/EC) (EP, 2009), officially published in October 2009, established a point of no return in Europe for the improvement of all aspects pertaining to crop protection. Improved crop protection processes with higher efficacy and efficiency could increase the benefits of plant protection products (PPP) while reducing the risk of environmental contamination and realizing better and high-quality food production and more sustainable agriculture. Currently, agriculture is considered a major contributor to water pollution owing to the use of nitrates, phosphates, and pesticides (Doruchowski et al., 2014).

This directive required all EU Member States (MS) to establish dedicated buffer zones, defined as permanently vegetated areas of land that are managed separately from the remainder of a field or catchment for the runoff of various agricultural pollutants (Muscutt et al., 1993). The specific characteristics of these zones are defined in each MS's National Action Plan (NAP). Among other technical information and specifications, the NAP must include the minimum requirements for buffer zone widths and its relation with different spray application techniques, mainly in terms of its capacity to reduce/avoid drift, and therefore, the risk of environmental damage. It is therefore clear that drift measurement methodologies along with an accurate classification scheme for every single sprayer/technology based on the potential contamination risk are essential tools.

Spray drift, defined as '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' (ISO, 2005) can be one of the most important (or main) factors affecting the risk of

---

* Corresponding author. Tel.: +34 93 552 21 099.
E-mail address: emilio.gil@upc.edu (E. Gil).

http://dx.doi.org/10.1016/j.agrformet.2014.12.002
0168-1923/© 2014 Elsevier B.V. All rights reserved.

environmental pollution with pesticides, and therefore, there is a strong need for drift measurement methods. Moreover, according to the measured values, standardized protocols for the classification/evaluation of different spray technologies based on their risk of contamination are also required. These two steps will allow the MS to proceed with a proportional definition and sizing of buffer zones that are more adapted to particular situations.

In the last few years, several studies aimed at evaluating and quantify the effect of the different parameters involved in spray drift. Nevertheless, considerable effort is required to classify different crop protection techniques in spray drift reduction classes (ISO, 2006). This is further complicated by the fact that these classes frequently vary greatly because of the influence of weather conditions (van de Zande et al., 2000, 2010; Balsari et al., 2007) and by differences in the measurement protocols and techniques (Arvidsson et al., 2011).

In most cases, the spray drift measurements in the field follow the standardized protocol established by ISO 22866:2005, resulting in very complicated and time-consuming experiments (Phillips and Miller, 1999; Ravier et al., 2005; Carlsen et al., 2006; de Schampheleire et al., 2008; Rimmer et al., 2009) and even a high dependence on external factors. Moreover, field experiments with different spraying systems cannot be performed under directly comparable and exactly repeatable conditions. Information about the driftability of an intended sprayer configuration can typically be obtained; however, these results are unsuitable for establishing any type of ranking or classification because of their great variability. The difference in drift reduction capabilities can therefore generally be determined only through sufficient repetitions under similar conditions and pair-wise comparison. The fall-out drift measurements presented in literature (Arvidsson et al., 2011) can, in some cases, differ by as much as a factor of 10 for the same nozzle size and working pressure, which can be attributed to different factors such as the weather conditions and spray application technology (Nuyttens et al., 2006). Arvidsson et al. (2011) found 0.20% and 0.94% variations in drift per degree temperature and per $m\,s^{-1}$ wind velocity, respectively.

Therefore, various studies have proposed alternatives for drift measurements in an attempt to develop easy, repeatable, and precise methods as complementary procedures to actual standards. One of the proposed alternatives, related to field crop sprayers, is Balsari et al.'s (2007) use of an ad hoc drift test bench. This method allows the drift potential value (DPV) to be quantified during a simulated application process with selected working parameters. Gil et al. (2014) used this method for measuring the DPV of a range of conventional and air injection flat fan nozzles. Their results demonstrated that the drift test bench can be considered an adequate complement to actual standard protocols for field measurements of drift (ISO, 2005). van de Zande et al. (2014) found similar results for field measurements (ISO 22866) using a test bench, and they ranked the nozzles that were similar in terms of drift reduction classes. Other indoor tests reported good correlation between the drift reduction potentials from the test bench and the wind tunnel measurements (Nuyttens et al., 2014).

ISO's ad hoc working group for drift measurements (ISO TC 23/SC 6/WG 16) officially adopted the test bench as a new method for measuring the drift potential of horizontal boom sprayer systems (ISO, 2014). However, further investigations are required to clarify the effect of environmental conditions (mainly wind velocity and its relative direction to the bench) to define the maximum limits for these wind factors so as to avoid a negative influence on the results. Vanella et al. (2011) concluded that this method needs relatively stable atmospheric conditions, as the combined effects of wind velocity and direction significantly affected the drift potential of the sprayer.

In the context of improving the present ISO draft standard concerning drift potential measurements by the use of test bench, the aim of the present study was to evaluate the effect of wind velocity and wind direction on the DPV in order to define a wind velocity threshold value to indicate in that ISO methodology. Repetitive field trials were made keeping all the other sprayer working parameters (forward velocity, nozzle characteristics, working pressure, and boom height) constant. For this purpose a reference spraying system defined according to ISO 22369-2 was tested through 20 repetitions.

2. Materials and methods

2.1. Experimental design

The bench consists of a 12 m × 0.5 m steel frame with slots for collectors (Petri dishes) situated at 0.5-m intervals (Fig. 1). Each slot is equipped with a sliding cover that makes it possible to cover/uncover the collector as needed. Once the boom sprayer passes by the entire bench, a pneumatic system automatically uncovers the collectors to capture the spray fraction that remains suspended in the atmosphere behind the boom before settling after some time. The purpose of the bench is to collect and quantify, in the absence of wind, the potential drift fraction, defined as the spray fraction that remains suspended over the bench immediately after the sprayer pass and that can be carried out of the target zone by weather air currents (Balsari et al., 2007).

A 12-m-long stainless steel bench was placed at the centre of the right-hand-side spray boom of the sprayer at 3.0 m from the centre axis of the tractor in coincidence with the middle point of the right-hand side of the boom (Gil et al., 2014), maintaining a NW-SE position relative to the wind direction. Artificial collectors with a capture area of 153.94 cm^2 (Petri dishes with 14-cm diameter) were placed at 0.5-m intervals along the bench slots. The sample position was 0.30 m above the ground, as recommended by ISO (2014). The first two collectors remained permanently uncovered whereas the others on the bench (length: 10 m) were initially covered using the sliding plates of the test bench. The sprayer started application using only the right-hand side of the boom half over the bench, spraying a 2 mg/L solution of water and tracer (yellow Tartrazine E 102). The spray track started 20 m before the bench and then moved over the bench with the covered collectors. Spraying was continued for a further 20 m after the end of the test bench, for a total spray length of 52 m. After the sprayer passed over the end of the bench and reached a point exactly 2 m beyond the last covered collector, an automatic pneumatic system activated the sliding covers initiated by the passing spray boom, which revealed the Petri dishes so as to capture the droplets still airborne over the bench. Droplets were collected for 60 s after the opening of the system. Every single Petri dish was then covered, adequately labelled, and placed in dry and dark conditions until the laboratory determination of the tracer concentration. To determine the presence of tracer as background in the environment before each trial, two open Petri dishes were placed on the bench and picked up before the next spray test. The tracer concentration at the artificial collectors was quantified using a spectrophotometer (Thermo Scientific Genesys 20).

Field trials were conducted 20 times using a conventional mounted 12-m boom sprayer (Ilemo Hardi, S.A.U., Lleida, Spain). The working pressure (3.0 bar), sprayer forward speed (6 $km\,h^{-1}$), boom height above the test bench surface (0.5 m), and nozzle type and size (XR 110 03 flat fan nozzle 110° Teejet®, Spraying Systems Co., Wheaton, IL, USA) were selected according to the reference spraying system (ISO, 2010) and maintained constant during all the tests (Fig. 2). The resulting spray volume rate was 236 $L\,ha^{-1}$.

During the tests, weather conditions such as the wind velocity, wind direction, air temperature and relative humidity were

Download English Version:

https://daneshyari.com/en/article/81572

Download Persian Version:

https://daneshyari.com/article/81572

Daneshyari.com