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Research Paper

Assessment of spray drift from pesticide applications in soybean crops

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Determining the downwind behaviour of sprays generated by different equipment is fundamental in managing pesticide applications. The objective of this study was to establish spray drift curves for soybean crops (*Glycine max*) in Brazilian meteorological conditions using different spray nozzles and to compare them with the model coefficients generated in European conditions. The study was conducted in Uberlândia, MG, Brazil, in a completely randomised block design with a split plot arrangement (4 × 20), with 10 replications. The study measured ground spray drift deposits by applications with a spray volume of 150 l ha^{-1} and four nozzle types: flat-fan standard and venturi – XR (fine spray) and AIXR (coarse spray); wide angle standard flat-fan and venturi – TT (medium spray) and TTI (very coarse spray), at 20 different sampling distances downwind, parallel to the crop line outside the target area, spaced 2.5 m apart. The deposits on filter paper placed on the soil were evaluated using a fluorescent tracer added to the tank of a boom sprayer and quantified by fluorimetry. Three drift prediction models were obtained for the soybean crop, considering the 90th percentile, for the nozzles XR, TT and AIXR, with exponential tendencies for four parameter regression models. The coefficients obtained were statistically different from those of the Dutch Drift Model for cereal cultivation and from those of the German Drift Model for field crops. Drift was reduced by increasing the size of the droplets produced particularly close to the cropping zones.

1. Introduction

Soybean (*Glycine max* L. Merril) is the most important oilseed in the Brazilian agricultural system and is the most cultivated and exported crop in the country (MAPA, 2015). The capacity to produce high yields and high quality has been a challenge for many producers with the increasing occurrence of pests, diseases and weed infestations which have driven producers to increase their use of pesticides.

In many cases, lack of technical knowledge about the product and application technology has resulted in the indiscriminate use of these products, causing problems regarding phytotoxicity and environmental contamination,

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mainly due to spray drift. Losses that occur within the field (i.e., material that is not deposited on the leaves of the crop but falls on the soil) can be considered as endodrift, while losses outside the treated area can be considered exodrift (Souza, Cunha, Pavanin, 2011).

The sprayed droplets can contaminate unwanted areas and cause serious consequences, including damage to adjacent crops sensitive to the products, environmental contamination and risks to the health of people and animals (Nuyttens, De Schampheleire, Verboven, Sonck, 2010). Thus, it is important to establish the risk of drift and the safe distances between the application and presence of people, open bodies of water and animals.

To estimate drift resulting from an application, specific regression models have been created, initially in Germany, known as the German Drift Model, based on percentage curves of drift deposited on soil downwind, from the border of the target crop to crops such as cereals, vines and fruit trees (Ganzelmeier et al., 1995; Rautmann, Streloke, Winkler, 2001), and later in the Netherlands for cereals, fruit trees, potatoes, bare soil (fallow area) and others, known as the Dutch Drift Model or IMAG (exponential regressions with four parameters) (Holterman & van de Zande, 2003).

However, both models were established under European meteorological conditions, which are considerably different from the conditions found in Brazil and South America in general (Peel, Finlayson, & Mcmahon, 2007). Also, none of the models proposed estimates spray drift for the widely cultivated crops in Brazil, such as soybeans.

In estimating drift, the type of nozzle can directly influence the estimate, as the fine droplets produced by conventional flat-fan and hollow-cone nozzles are more likely to be carried by the wind when compared to coarse droplets produced by pre-orifice and air induction nozzles (Tsai et al., 2005; Stainier, Destain, Schiffers, Lebeau, 2006; Yarpuz-Bozdogan & Bozdogan, 2009; Nuyttens et al., 2011; Hilz & Vermeer, 2013).

Flat-fan nozzles with air induction ports (AIXR) can provide lower potential drift compared to simple flat-fan nozzles (XR) as shown in studies performed in Italy and Spain (Gil et al., 2014). In Kopais, Greece, lower drift deposits were observed on bare soil when using air-induction nozzles (AIXR 11002 and 04) compared to similar standard flat-fan nozzles of local production. The air-induction nozzles 11002 and 11004 significantly reduced drift at distances of 2 and 6 m from the target application area, respectively (Kasiotis, Glass, Tsakirakis, Machera, 2014).

Thus, the present study sought to establish ground deposit drift curves for sprays applied to soybeans under Brazilian meteorological conditions using various spray nozzle types and comparing these curves to the drift potential curves produced by the German and Dutch Regression Models.

2. Material and methods

2.1. Field and crop characterisation

The experiment was conducted at the Capim Branco Experimental Farm, belonging to the Federal University of Uberlândia, located in the city of Uberlandia, Minas Gerais, Brazil.

The area is located at an altitude of 837 m, 18° 53′ 287″ S latitude and 48° 20′ 514" W longitude, with flat topography and a tropical humid climate with dry winters. The laboratory evaluations were performed at the Agricultural Mechanisation Laboratory (Laboratório de Mecanização Agrícola - LAMEC), part of the Institute of Agricultural Sciences (Instituto de Ciências Agrárias – ICIAG/UFU), also located in Uberlândia.

For the drift evaluation assay, a soybean plot was seeded in a field with a centre pivot irrigation system on November 16, 2013. The area was harrowed seven days before sowing, and cultural and crop protection treatments were performed per the needs of the crop. Evaluations took place between January 29 and February 6, 2014, when the crop was at the R4 (fully developed pods) and early R5 (beginning of grain filling) stages, according to the classification of soybean development stages proposed by Fehr and Cavisess (1977). Soybean plants were erect, measuring on average 800 mm in height, with a leaf area index (LAI) of 4.1:1 (Watson, 1947).

2.2. Spray nozzle and experimental design

Using a completely randomised block design with a split plot arrangement (4 × 20), with 10 replications, drift resulting for spray applications was assessed using four different nozzles types at 20 different sampling points (corresponding to the distances of the drift collectors from the target application area) amounting to 40 experimental plots and 800 split plots (Table 1).

2.3. Characterisation of the physical chemical properties of spray liquid and tracer

Before starting the drift assessments, the physicochemical properties of the spray were characterised, including pH, electrical conductivity, density, viscosity and surface tension, according to the method used by Cunha, Alves and Reis (2010). Thus, samples were obtained for the water before preparation of the spray liquid and after addition and mixing of the dye. Seven replicates were collected from each sample (water and water + dye). These specimens were identified and stored in a cooler, in the absence of light, for assessing their physicochemical properties in the laboratory. Evaluations were performed by collecting aliquots from the original solution prepared for field testing, with temperature measured using a digital thermometer with a resolution of 0.1 °C and an accuracy of ±0.4 °C. The purpose of these tests was to characterise the physical chemical properties and verify if the addition of dye could promote some difference on these properties.

2.4. Field arrangement for the ground deposit drift tests

To quantify the deposited drift, horizontal collectors were placed at ground level downwind of the application site, parallel to the cultivation row outside the target area (area with no cultivation) (Fig. 1). Filter paper was used as collectors with dimensions of 38 × 7 cm (266 cm^2) and a weight of 65 g. These collectors were distributed every 2.5 m, up to a maximum distance of 50 m from the target area; at each distance, four collectors were lined up side by side, separated by 1.5 m (the total area of the collectors was 1064 cm^2). To prevent the