Investigating the variance of edge-of-field deposits of spray drift

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1. Introduction

Spray applications in arable crops often lead to off-target spray deposits downwind from the treated field. Throughout several decades, many experiments have been carried out by different researchers to quantify the downwind spray deposits. Relations between downwind spray deposits and parameters like sprayer settings, field conditions and environmental conditions were investigated. Still, there is a large variance in the observed data that cannot be explained satisfactorily by the experimental and environmental conditions. Sprayer boom movements and local fluctuations in driving speed, wind speed and wind direction are the most likely factors affecting variance in downwind spray deposits.

In this study variations in downwind spray deposits caused by sprayer boom movements are investigated both experimentally and based on quasi-dynamic simulations using the spray drift model IDEFICS.

2. Materials and methods

Downwind deposits of spray drift were measured next to a potato field (102 m long, 72 m wide) in order to quantify the variance of spray deposits alongside the field edge. Deposits of spray drift were measured at the crop-free edges surrounding the field. The sprayer used was a 24 m wide Hardi Commander (Twin Force), driving at 6.0 km·h^{-1} (1.7 m·s^{-1}) (Figure 1). Wind speed and direction were recorded during the experiments. Horizontal sprayer boom movements were measured using a laser distance indicator (DME200; Sick BV, The Netherlands); measuring frequency ca. 200 Hz. Sprayer boom height was measured using an ultrasonic device (P42-A4N-2D-1C1-13; PIL Sensoren GmbH, Germany); measuring frequency ca. 48 Hz. The ultrasonic device was connected to the tip of the boom and measured the height above the bare soil strip next to the potato field. The soil strip was flattened to obtain accurate height readings. The experiment involved 6 repetitions.

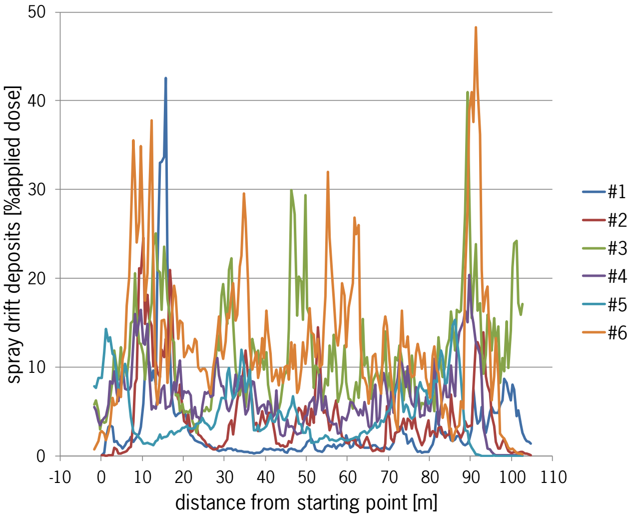
The IDEFICS spray drift model was developed to estimate averaged downwind deposits of spray drift when spraying arable crops, for different sprayer settings and environmental conditions [1]. However, sprayer boom movements and other local variations (e.g. varying driving speed or environmental conditions) were not accounted for. Typically, a full-field IDEFICS simulation run involves computing the flow paths through air of about 30,000 droplets per nozzle. In real time, this represents only a very short time scale (~ms). Typically, local variations of boom movements or wind direction occur at a much slower time scale. Therefore, the effect of such local variations on spray drift may be simulated by a set of simulations representing static cases at appropriate time intervals with different conditions. Adding the results of these simulations, taking into account that the sprayer moved forward between consecutive time steps, results in a quasi-dynamic behaviour of spray drift in time and space.

Figure 1: Tractor and Hardi Commander sprayer driving through potato field, parallel to a bare soil field. Filter strips parallel to the field edge allow measuring variation in spray drift deposits along the edge.

3. Results and discussion

3.1. Experiments

Figure 2-left shows the results of the measured spray drift deposits 2 m downwind and alongside the treated field, for each of the 6 repetitions. The graph clearly shows that variance of deposits was very large, particularly near the beginning and the end of the track, where the tractor accelerated and decelerated, respectively. The experiments indicated that with the horizontal sprayer boom movements the most important frequencies appeared to occur around 0.25 and 0.50 Hz. These frequencies were studied in the simulation model. In the central part (40-60 m) the coefficient of variance (CV) was about 50%.



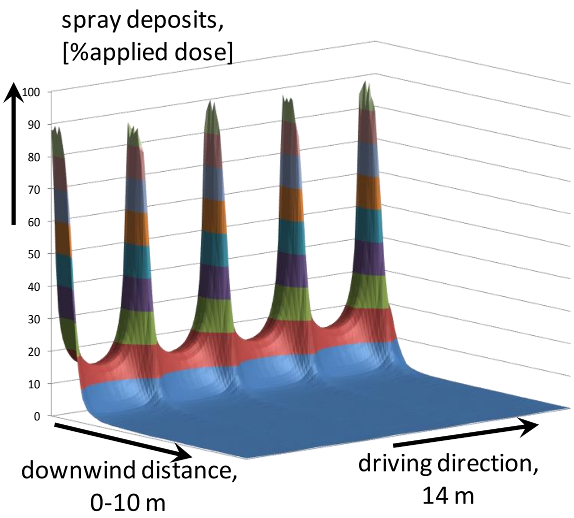


***Figure 2:** Left: measured spray drift deposits at 2 m downwind from the treated field, as a function of distance alongside the field; 6 repetitions are shown; right: simulated spray deposits downwind for sinusoidal horizontal sprayer boom movements at 0.50 Hz*

3.2. Simulations

Figure 2-right shows the results of the simulations for sinusoidal horizontal boom movements at a frequency of 0.50 Hz. The simulation mimicked the experiments, assuming a sprayer equipped with XR11004 nozzles spraying at 3 bar, crop height 0.5 m, boom height 0.35 m above the crop, forward speed 1.67 $m \cdot s^{-1}$ and wind speed 3.5 $m \cdot s^{-1}$. At 2 m downwind the CV was 50%, at 5 m downwind CV was 37%. At a fixed distance from the field edge in the simulation shown, the highest deposits appear to be 5 times higher than the lowest deposits.

4. Conclusions

Both experiments and simulations showed that sprayer boom movements can cause significant variance in downwind spray deposits. CVs from field experiments and simulations appear to be similar. The large difference between highest and lowest spray drift deposits may have severe consequences for non-target organisms in the off-target area close to the treated field.

5. References

[1] Holterman HJ, Van de Zande JC, Porskamp HAJ, Huijsmans JFM. 1997. Modelling spray drift from boom sprayers. Comp & Electr in Agric 19:1–22.

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