EVALUATION OF DIFFERENT WIND TUNNEL PROTOCOLS FOR SPRAY DRIFT RISK ASSESSMENT

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Abstract

46 Wind tunnel measurements were carried out to measure airborne and fallout spray volumes for 10 different spray nozzles. Based on these measurements, drift potential reduction percentages (DPRP), expressing the percentage reduction of the drift potential compared with the reference spraying, were calculated following three different approaches ($DPRP_{V1}$, $DPRP_{V2}$ & $DPRP_{H}$). The results showed the expected fallout and airborne spray profiles and the effect of nozzle type and size on DPRP values was demonstrated. For the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_{H}$ while for the low-drift nozzles opposite results were found. For the air inclusion nozzles, there was a relatively good agreement between $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_{H}$ values. All of this is important in the interpretation of wind tunnel data for different nozzle types and sampling methodologies.

A comparison was made between the results obtained from the wind tunnel measurements and the results from direct field drift measurements. Results showed that in the wind tunnel, driftability experiments can be made with different spraying systems under directly comparable and repeatable conditions and this methodology is well suited to permit relative studies of drift risk. The wind tunnel approach, calculating the surface under the measured fallout deposit curve ($DPRP_{H}$), was best suited to represent real near-field sedimenting drift characteristics.

Introduction

Within the framework of a research project about spray drift from field sprayers, different spray application techniques have been tested using three different risk assessment means which are PDPA laser measurements (Nuyttens et al., 2006, 2007 a), wind tunnel measurements (Nuyttens, 2007) and field drift measurements (Nuyttens et al., 2007 b). These experiments have been used to perform a spray drift risk assessment (De Schampheleire et al., 2006) and to develop a CFD drift model for field sprayers (Baetens et al., 2007). This paper presents results from the wind tunnel measurements following three different approaches. The results obtained with this indirect drift assessment mean are compared with the ones from the field measurements to evaluate its potential for drift risk assessment.

Materials and Methods

Spray application techniques

An overview of the tested spray nozzles at a pressure of 3.0 bar and a height of 0.5 m is presented in Table 1. The reference spraying is defined as a Hardi ISO F 110 03 standard flat fan nozzle. This reference spraying is used for a comparative assessment of the different spray applications.

Nozzle	Flow rate (*l* min^{-1})	Nozzle	Flow rate (*l* min^{-1})
Hardi ISO F 110 02	0.80	Hardi ISO LD 110 03	1.20
Hardi ISO F 110 03[a]	1.20	Hardi ISO LD 110 04	1.60
Hardi ISO F 110 04	1.60	Hardi ISO Injet 110 02	0.80
Hardi ISO F 110 06	2.40	Hardi ISO Injet 110 03	1.20
Hardi ISO LD 110 02	0.80	Hardi ISO Injet 110 04	1.60

[a] Reference spray application

Wind tunnel measurements

46 wind tunnel experiments were carried out in the Silsoe Research Institute (SRI) wind tunnel facility. Measuring set-up and protocol have been described by Nuyttens (2007). An overview is presented in Figure 1. Single and static nozzles at a height of 0.50 m were exposed to a wind tunnel air speed from 2 m s^{-1}. Exposure time was 10 s. Drift risk was assessed by measuring the quantities of spray deposited downwind of the nozzle on horizontal 2 mm diameter polythene lines in a vertical ($V_1 \rightarrow V_5$) and a horizontal array ($H_1 \rightarrow H_6$) using a water-soluble fluorescent tracer (sodium fluorescein at 0.02%)(Fig. 1). Values for

deposits have been normalised to a common rate of liquid emission by the nozzle and are expressed as the volume of spray recovered from the lines (in µ*l*) for every litre of spray solution that has been emitted by the nozzle. Drift potential values of the different spray nozzles are compared with the equivalent results obtained from the reference spraying by calculating their drift potential reduction percentage (DPRP, %) following three different approaches. $DPRP_{V1}$ was calculated based on the first moment of the airborne deposit profiles, $DPRP_{V2}$ based on numerical integration of the airborne deposit curves and $DPRP_{H}$ based on numerical integration of the fallout deposit curves.

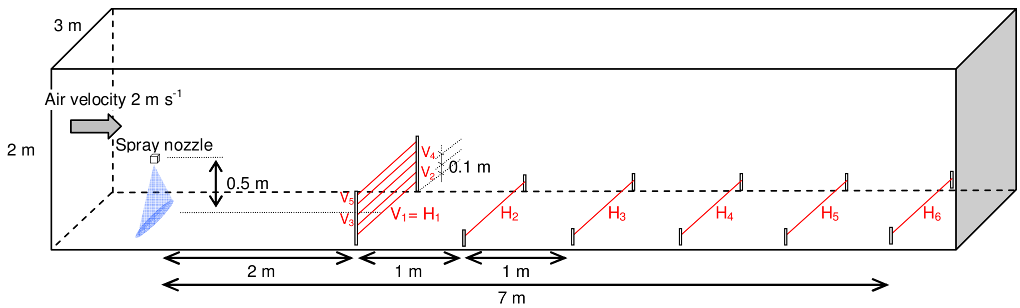

Figure 1. Wind tunnel measuring setup with the different collector lines (airborne deposits: $V_1 \rightarrow V_5$ and fallout deposits: $H_1 \rightarrow H_6$)

Field drift experiments

Field drift measurements have been carried out according to ISO 22866. The measuring set-up, protocol and the data processing are described in detail by Nuyttens et al. (2007 b). The total drift reduction potential (DRP_t, %) of the different nozzles (Table 1) was calculated by comparing the surface under the measured drift curve with the surface under the predicted drift curve of the reference spraying, for the same weather conditions. DRP_t values were compared with DPRP values to evaluate the potential of the different wind tunnel protocols for spray drift risk assessment. All field drift experiments were performed on a flat meadow at a driving speed of 8 km h^{-1} and with a boom height and nozzle distance of 0.50 m.

Research Results

DPRP values based on the three different approaches ($DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_{H}$) are presented in Fig. 2 together with the corresponding 95% confidence intervals. In Fig. 3, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_{H}$ values resulting from the wind tunnel measurements are compared with the corresponding DRP_t values

(Nuyttens et al., 2007 a) from the field drift experiments for the different nozzle types. The simple linear regressions and their corresponding R^2 values are presented.

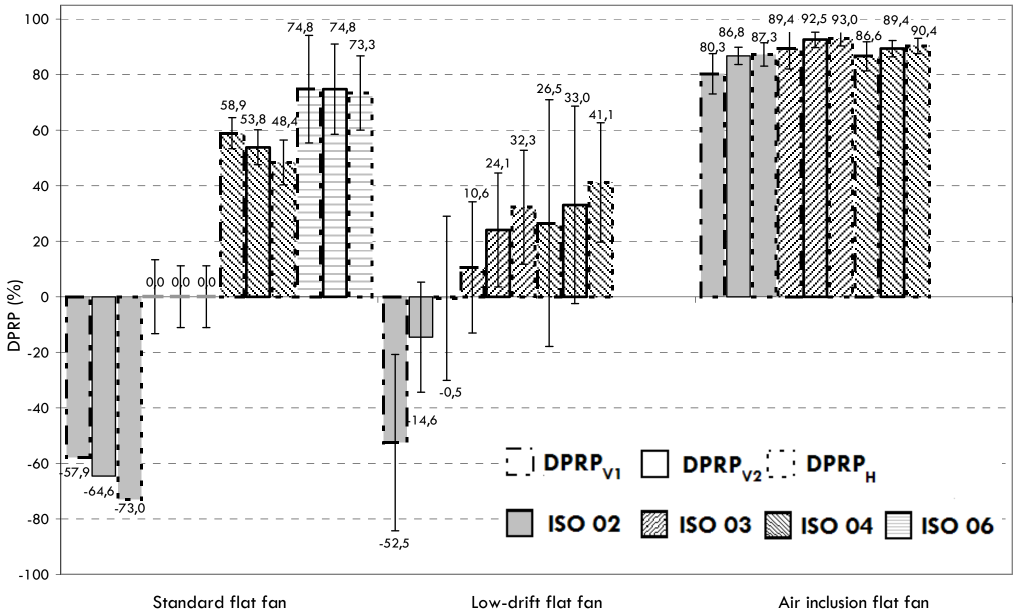

Figure 2. $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$ values and their 95% confidence intervals for the different nozzle types compared to the reference (Hardi ISO F 110 03 standard flat fan)

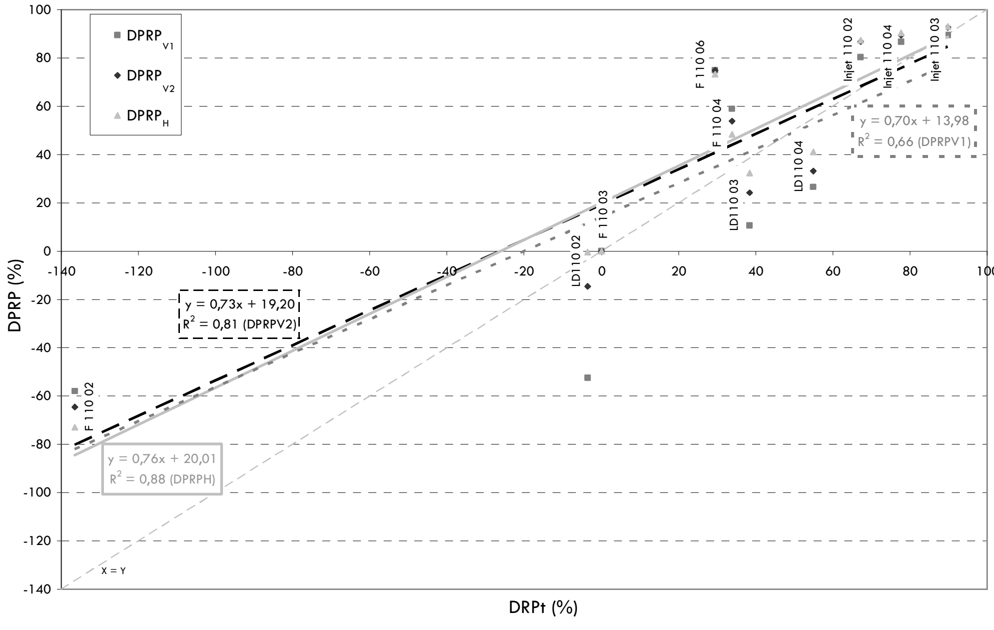

Figure 3. Comparison between DPRP and DRP_t values for different Hardi ISO nozzle types

Discussion and conclusions

It is clear that the nozzle type (standard, low-drift and air inclusion flat fan) has an important influence on the drift potential (Fig. 2). For one and the same nozzle size, DPRP values of the air inclusion nozzles are always higher than DPRP values of the standard flat fan and the low-drift flat fan nozzles and differences are statistically significant. In case of ISO 02 and ISO 03 nozzle sizes, low-drift nozzles have higher DPRP values compared with standard flat fan nozzles. The effect of nozzle type is most important for smaller nozzle sizes.

Besides nozzle type, the size of the nozzle is also related to the drift potential. In general, for the standard flat fan nozzles and the low-drift nozzles, DPRP values increase with increasing nozzle sizes. For the air inclusion nozzles, the effect of nozzle size on DPRP values is less clear and in general statistically not significant.

Comparing results conducted by the three different wind tunnel approaches namely, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$, some interesting conclusions can be drawn (Fig. 2). For the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_H$. This means that by comparing with the reference spraying, airborne deposits are relatively lower than fallout deposits. For the low-drift nozzles opposite results were found. $DPRP_H$ values were the highest followed by $DPRP_{V2}$ and $DPRP_{V1}$. For the air inclusion nozzles, a relatively good agreement between $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$ values was found. All of this is important in the interpretation of wind tunnel data for different nozzle types and sampling methodologies.

From Fig. 3, it is clear that there is a fairly good linear relation between DRP_t and DPRP values for the different spray nozzles with R^2 values of 0.66, 0.81 and 0.88, respectively for, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$. Hence, from the three wind tunnel approaches, the approach calculating the surface under the measured fallout deposit curve is best suited to represent real near-field sedimenting drift characteristics. Despite the fairly good correlation between DRP_t and DPRP values, there are some important discrepancies which are important to keep in mind when interpreting wind tunnel results. The deviation of the first-order regression lines from the bisector is mainly caused by the leverage effect and the results of the F 110 02 nozzle with its relatively high DPRP values compared with the corresponding DRP_t value of -136.5%. Among the other standard flat fan nozzles, a considerable and statistically significant difference between DRP_t and DPRP values is also observed for the F 110 06 nozzle. Although for the ISO 03 and ISO 04 standard flat fan nozzles, there is a good agreement between DRP_t and DPRP values, it can be seen that DPRP values are generally higher than DRP_t values for the standard flat fan nozzles. Knowing that for the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_H$, it is clear that $DPRP_H$ corresponds best with DRP_t results. For the different sizes of low-drift nozzles, a good agreement between wind tunnel and field drift results is found. In contrast with the standard flat fan nozzles, DPRP values are generally lower than DRP_t values. Because for this nozzle type, $DPRP_{V1}$ values were the lowest followed by $DPRP_{V2}$ and $DPRP_H$, $DPRP_H$ again corresponds best with DRP_t.

In conclusion, results showed that in the wind tunnel, driftability experiments can be made with different spraying systems under directly comparable and repeatable conditions and this methodology is well suited to permit relative studies of drift risk. The wind tunnel approach, calculating the surface under the measured fallout deposit curve ($DPRP_H$), was best suited to represent real near-field sedimenting drift characteristics. Wind tunnel experiments permit a drift potential to be calculated to assess relative drift risk but it is difficult to investigate effects like driving speed, air assistance and weather conditions where direct drift measurements are necessary. Moreover, field research is appropriate for obtaining realistic absolute estimates of drift under a range of working conditions but it is time-consuming and expensive.

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