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Proceedings BCPC Conference Pests & Diseases, Brighton (UK), 13-16 November. Farnham

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https://www.bcpc.org/wp-content/uploads/2022/08/Pests-and-Diseases-Conference-2000-Session-2B-and-2C.pdf#page=23

The effect of windbreak height and air assistance on exposure of surface water via spray drift

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ABSTRACT

In a series of field experiments spray drift was assessed when spraying a sugar beet crop. Next to the crop, the field margin was planted with a 1.25m wide strip of *Miscanthus* (Elephant grass). To evaluate the effect of different heights of such a windbreak crop on spray drift it was cut at different heights just before spraying. Heights varied between: not planted (0m), at crop height level (0.5m), 0.5m above crop height (being sprayer boom height, 1.0m) and 1m above crop height (1.5m). Spraying was performed with a conventional and an air-assisted sprayer. Spray volume was 300 l/ha using Medium spray quality nozzles. Spray drift was measured as soil deposit up to 15m from the last nozzle using surface collectors. The height of the windbreak had a clear effect on spray drift deposit. Spray deposit at 3-4m distance from the last nozzle decreased significantly with increasing heights of the *Miscanthus*. When *Miscanthus* was cut to equal height as the sugar beet spray drift reduction was 50% compared to spray drift on the same distance when no windbreak was grown. With the 0.5m and 1.0 above crop height levels of *Miscanthus* spray drift was reduced by respectively 80% and 90%. On average the air assisted sprayer reduced spray drift by 70%. The effect of these results on predictions of surface water exposure is discussed.

INTRODUCTION

The Multi Year Crop Protection Plan (MYCPP, 1991) of the Dutch government formulates objectives for a reduction in plant protection products to be used and for an application practice for these products which is safe and more compatible with the environment. The emissions of plant protection products to soil, (surface)water and air should be reduced. Regulations are embedded in both the Pesticide Act and the Water Pollution Act. Based on the spray drift deposition level in surface water, the width of crop-free bufferzones can be set and impacts on the registrability of agrochemicals determined. A general reduction in spray drift to surface water next to the sprayed field can be achieved by improvements in spray application techniques. For the last 10 years an intensive measuring programme on spray drift has been performed (Van de Zande *et al*., 2000). Porskamp *et al*. (1994) concluded that a windbreak hedgerow next to an orchard reduced spray drift by 70-90%. For the Dutch situation De Snoo & de Wit (1998) showed that leaving the outer 3m of the crop unsprayed gave a drift reduction of 95% to adjacent ditches. Miller *et al.* (2000) suggest that canopy structure and height has its effect on spray drift reduction. Because no data were available on the reduction in spray drift of the effect of the height of a windbreak crop next to an arable crop, field experiments were performed. A comparison was made between a conventional field sprayer and an air-assisted field sprayer and three heights of a windbreak crop (Elephant grass *Miscanthus ssp.*) when spraying sugar beet.

MATERIALS AND METHODS

Spray drift was measured spraying a downwind swath of 24m of a sugar beet field. The length of the sprayed track was 35m. A minimum of nine replications were made in time. Measurements of spray drift were performed using a reference situation i.e. a field sprayer, with Medium spray quality nozzles (Southcombe *et al*., 1997), applying a volume rate of 300 l/ha and a sprayer boom height of 0.5m above crop canopy. Specifications of the sprayer used in the experiments are as summarised in Table 1.

Table 1. Settings of the field sprayer during spray drift field experiments

sprayer	Hardi Commander Twin Force
working width [m]	24
nozzle type	XR 110.04VP
spray pressure [bar]	3.0
spray quality	Medium
nozzle flow rate [l/min]	1.58
driving speed [km/h]	6.0
spray volume [l/ha]	316
air assistance oil pressure (bar)	240

Average height of the sugarbeet crop was 0.5m. The windbreak crop of *Miscanthus* (Elephant grass) was planted in two rows. Row spacing of the *Miscanthus* was 0.65m, average canopy width was 0.95m, and distance between last sugar beet row and the first *Miscanthus* row 1.0m. Total windbreak canopy was therefore on a zone of 2.25m, virtually between the last crop row and the ditchbank. The windbreak crop was cut at heights equal to the sugarbeet crop (0.5m), 0.5m above crop height (is sprayer boom height) and 1.0m above crop height, respectively 1.0 and 1.5m high. Spray drift measurements were performed for a standard sugarbeet field lay-out, a crop free zone of 2m, and three heights of a *Miscanthus* windbreak crop of 1.25m width on this crop free zone.

A fluorescent tracer (Brilliant Sulfo Flavine; BSF 1g/l) and a non-ionic surfactant (Agral; 1g/l), solubilised in the spray liquid, were used to analyse spray deposit. Spray deposit was measured next to the field up to 15 m from the last nozzle. Ground deposit was measured on horizontal collection surfaces placed at ground level in a double row downwind of the sprayed swath. Collectors used were synthetic cloths with dimensions of 0.50x0.08 and 1.00x0.08 m. The collectors were placed at distances 0-0.5, 1-1.5, 1.5-2, 2-3, 3-4, 4-5, 5-6, 7.5-8.5, 10-11, 15-16 m from the last downwind nozzle. For the situations with the windbreak crop collectors were at the same distances starting at 2m from the last nozzle. The last nozzle of the field sprayer moved in the middle between the last and last but one crop-row of sugarbeet, 0.25m inside the last crop row. After spraying, the dye was extracted from the collectors. The deposited dose was measured by fluorimetry and expressed per surface area of the collector. The spray drift was expressed as percentages of the application rate of the sprayer (spray dose).

Meteorological conditions during the measurements were recorded. Wind speed and temperature were recorded at 5 s interval at 0.5 and 2.0 m height, using cup anemometers and Pt100 sensors, respectively. Relative humidity (RH) was measured at 0.5 m height and wind direction at 2.0 m height. Average weather conditions during the field experiments were as summarised in Table 2.

Table 2. Average weather conditions during spray drift field experiments

	temperature [^{o}C]		RH [%]	wind angle	windspeed [m/s]	
	0.5m	2.0m		^{o} to square	0.5m	2.0m
conventional	9,3	9,2	72	15	3,6	4,7
air assistance	9,8	9,7	69	17	3,5	4,6

Statistical analysis of the data was done on spray deposition on different zones next to the field, using analysis of variance (ANOVA 5% probability; Payne, 1993).

RESULTS

Spray drift deposition next to the field

The differences in spray drift deposition for the conventional field sprayer and the air-assisted field sprayer when spraying the standard sugarbeet field layout, and the field layout with different heights of *Miscanthus* next to it are presented in figures 1 and 2. When spraying conventionally, the increasing height of the *Miscanthus* decreases spray drift deposition behind the windbreak. With air assistance these effects remain the same. Levels of spray drift are for the air assisted field sprayer clearly lower than for the conventional operated field sprayer. In general spray drift deposition decreases with increasing distance. However figures 1 and 2 show that for the 1.0m high *Miscanthus* spray drift is very low on the zone 4-8m from the last nozzle and increases slightly again on larger distances, remaining at lower levels than with the other objects. As spray drift decreases with increasing distance, a statistical comparison is performed on discrete zones next to the field. In table 3 the spray drift deposition on different zones next to the field is presented with results of the statistical analysis (ANOVA $\alpha < 0.05$). These zones were chosen as being most important for the effect of drift deposition on the surface water area.

Table 3. Spray drift deposition (% of dose) next to the field on surface water distance, when spraying a sugar beet crop conventionally or with air assistance in combination with a crop-free bufferzone of 2m, or a windbreak crop of *Miscanthus* of 1.25m width of equal height, or 0.5m and 1.0m higher than crop canopy (0.5m)

bufferzone	conventional	air assistance
no	2.4 a	0.46 a
2m crop-free	1.5 b	0.20 b
Miscanthus, equal height	1.1 c	0.20 b
Miscanthus, + 0.5m high	0.40 d	0.11 c
Miscanthus, + 1.0m high	0.28 e	0.05 d

means within one column followed by the same letter do not differ significantly (ANOVA α<0.05)

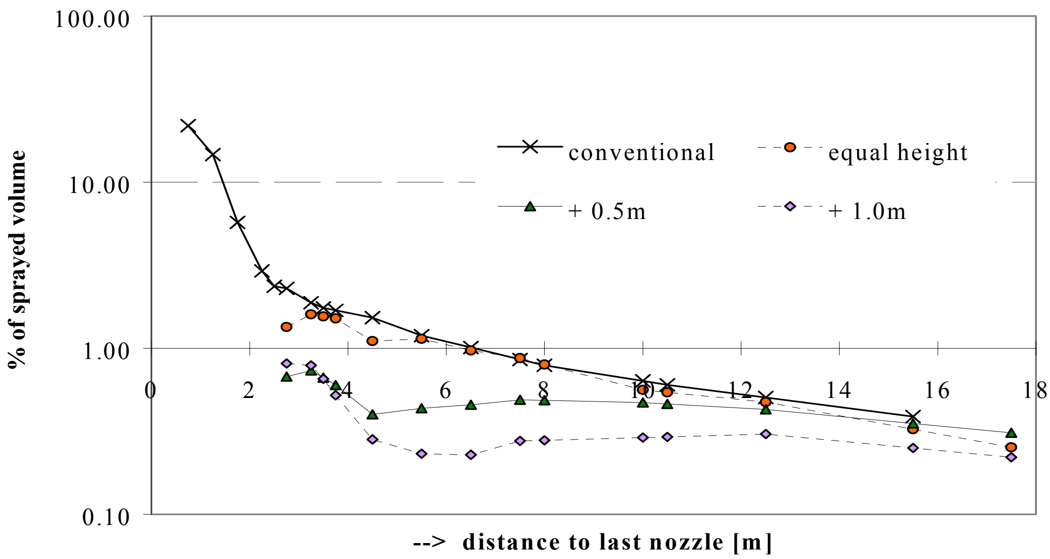

Figure 1. Spray drift deposition (% of sprayed volume) next to a sugar beet field sprayed conventionally with a standard field layout (conventional) and with a 2m strip of *Miscanthus* next to it of equal height, 0.5m (+0.5m) and 1.0m (+ 1.0m) higher than the sugar beet crop

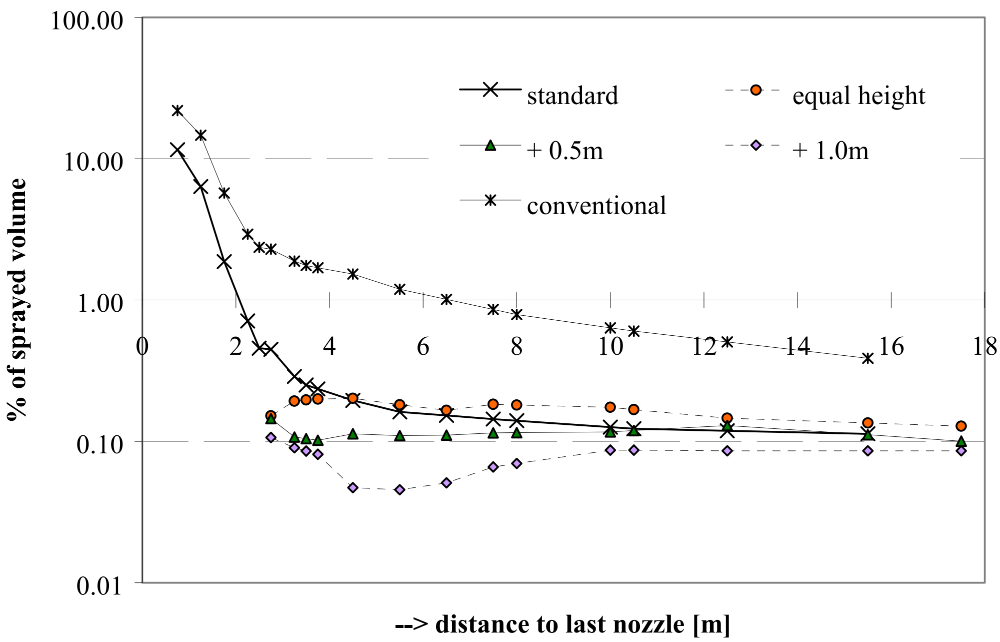

Figure 2. Spray drift deposition (% of sprayed volume) next to a sugar beet field sprayed with the aid of air assistance on the field sprayer with a standard field layout (standard) and with a 2m strip of *Miscanthus* next to it of equal height, 0.5m (+0.5m) and 1.0m (+ 1.0m) higher than the sugar beet crop, compared to standard field layout sprayed conventionally (conventional)

Spray drift reduction

The effect on spray drift for the different spray techniques can be expressed as the spray drift reduction relative to the spray drift deposition of the 'conventional" field sprayer for the standard field layout. Spray drift reduction on the areas next to the field is expressed as percentage of the deposition of the conventional field sprayer on the same area (Table 4).

Table 4. Average spray drift reduction (%) to the ground next to the field, on 4-5m distance from the last nozzle when spraying a sugarbeet crop using a conventional and an air-assisted field sprayer using Medium spray quality nozzles for a standard field layout (2 m crop-free) and when growing a *Miscanthus* windbreak of equal height, and 0.5m or 1.0m above crop canopy (0.5m) on this 2m zone.

bufferzone	soil deposition	
	conventional	air assistance
2m crop-free	36	92
Miscanthus, equal height	53	92
Miscanthus, + 0.5m high	83	95
Miscanthus, + 1.0m high	88	98

The growing of a strip of *Miscanthus* on a zone next to an arable crop like sugar beet decreases spray drift deposition on the surface water area next to the sprayed field. Spray drift is reduced with increasing height of the windbreak crop. On the distance 4-5m from the last nozzle average spray drift reduction is up to 88% for conventional spraying and up to 98% using an air-assisted sprayer. Air assistance reduced spray drift in general 70-80%.

DISCUSSION

In the Netherlands crops like sugarbeet are usually grown close to the the border of the field, in case of a ditch close to the ditch bank.When the distance between the last crop row and the ditchbank is 0.5m, for sugar beet the distance of the last nozzle of the field sprayer to the surface water is 2.25m (Figure 3).

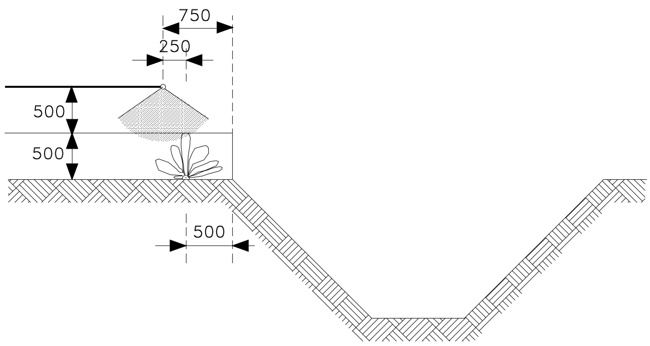

Figure 3. Typical lay-out of a field sprayer above a sugarbeet crop in the Netherlands. When the ditch-bank is 1.5m wide, the distance between the last crop-row and the surface water is 2.0m.

On 2-3 m distance from the last row of a sugarbeet crop, the area where in the Netherlands the surface water is, the spray drift deposition is significantly lower when crop protection products are applied with an air assisted sprayer. Applying on the downwind 24m of a sugarbeet field agrochemicals with an air assisted field sprayer, reduces spray drift with 85 to 90%, compared to a boom sprayer equipped with nozzles producing a Medium spray quality (300 l/ha). In combination with a 1.25m wide windbreak crop like *Miscanthus* grown on a zone of 2m width between the ditch-bank and the first crop-row, spray drift reduction can be increased depending on the height of the windbreak crop. Drift reduction increases from 53% for an equally high windbreak crop sprayed conventionally to 98% when spraying air-assisted in combination with a 1.5m high windbreak crop (1.0m higher than crop canopy).

ACKNOWLEDGEMENT

This work has been funded by the Ministry of Agriculture, Nature Management and Fisheries and carried out within the frame of the Research Program Ecotoxicological Risks of Crop Protection Products. The spraying equipment has been supplied by Hardi International A/S. We also wish to acknowledge the efforts of the people of the Oostwaardhoeve experimental farm for practical help carrying out these experiments.

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