Canopy density spraying of strawberries

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Summary

The reduction of the emission of plant protection products (PPP) to the environment is an important issue when applying agrochemicals in the Netherlands. Much attention has always been paid to reduce spray drift; however, an application having an use reduction in combination with the same level of spray drift reduction implicitly means higher levels of emission reduction of PPP to the surface water, as the amount of spray drift originates from a smaller amount of applied PPP. Therefore more attention is paid nowadays to more precise application methods of PPP applying only to the areas where the PPP is needed, the plant. In strawberries Canopy Density Spraying (CDS) was tested under practical conditions. The benefits for the environment are shown by means of reduced use of plant protection products (PPP) in order to maintain comparable spray distributions as with standard application techniques and maintain good biological efficacy. Angling of the air sleeve and nozzles towards the crop rows on the bed improved spray deposition compared to a horizontal spray boom and nozzle orientation. In both growth stages spray deposition on the leaves was for the CDS spray technique 15–25% higher compared to the standard air-assisted sprayer. Loss to soil surface on top of the bed and on the paths in between the beds was for the CDS sprayer lower than for the standard. Spray deposition above the crop rows was for the CDS sprayer higher than of the standard.

Key words: Precision agriculture, sensors, spraying, use reduction, variable rate application

Introduction

The reduction of the emission of plant protection products (PPP) to the environment is an important issue when applying agrochemicals in the Netherlands. Much attention always has been paid to reduce spray drift, however an application having an use reduction in combination with the same level of spray drift reduction implicitly means higher levels of emission reduction of PPP to the surface water, as the amount of spray drift originates from a smaller amount of used PPP. Therefore more attention is paid nowadays to more precise application methods of PPP applying only to the areas where the PPP is needed, the plant (Zande *et al*., 2008). In strawberries Canopy Density Spraying (CDS) was used under practical conditions (Michielsen *et al*., 2013; Nieuwenhuizen & Zande, 2012) and further improved by adapting nozzle orientation and air direction to the bed grown strawberry crop. The benefits for the environment are shown by means of reduced use of plant protection products (PPP) in order to maintain comparable spray distributions as with standard application techniques and maintain good biological efficacy. To show the differences between a CDS-sprayer and a standard application technique spray deposition measurements were done in two different crop growth stages of a strawberry crop.

Materials & Methods

Canopy Density Spraying for the application of fungicides and insecticides in strawberry (Fig. 1) was developed as a combination made of GreenSeeker sensors and pneumatic actuated multi-nozzle bodies (Lechler VarioSelect). The GreenSeeker sensors are able to measure the Near-infrared Difference Vegetation Index (NDVI) as a continuous measure of the amount of vital biomass present. The CDS-sprayer is based on a Hardi Twin air sleeve boom sprayer; Sensispray-Horti (Homburg, Stiens NL). The strawberries are grown on beds with a tramline distance of approx. 1.5 m width and a net bed surface of 1.20 m with two rows of plants. The sprayer consisted of three sections with a working width of 4.5 m. Above each strawberry bed one GreenSeeker sensor was mounted, which controlled the nozzle bodies. The nozzle bodies were mounted 0.25 m apart based on an implemented software algorithm relating measured NDVI and the spray volume in switching nozzle combinations (Michielsen *et al*., 2010) and thus varying spray volume. The sensors were configured at a 10 Hz update rate. To adjust spray volume, based on the Greenseeker measured vegetation index (NDVI), four nozzles (Unigreen 650033, 650050, 2*650067 at a spray pressure of 3 bar) mounted in Lechler Varioselect nozzle bodies were switched on or off individually or jointly. Nozzles were positioned in the nozzle bodies in such a way that in the smallest growth stage only the nozzles on top of the crop row were spraying. As crop canopy increases in size in time more nozzles were opened to the left and right hand side until the total plant row of the strawberries on the bed was sprayed. The paths in between the beds were not sprayed at all. Additionally the air assistance sleeve outlet was adapted to crop row position on the bed. The sleeve and the nozzle bodies were therefore angled towards the crop rows as two focussed air and spray tunnels per bed (1.20 m net). The effect of these settings was evaluated on a patternator (Fig. 2) showing the individual spray distribution of the angled nozzles and of the four nozzles together. It also shows that the spray is more focussed on the plant rows and widens with increase number of nozzles spraying. The specific task of volume rate adjustment was accomplished by tailor made decision algorithms to assure correct application rates for practical circumstances. The benefits of this canopy density based spraying system are expected because the tracks of the tractor and paths between beds are not sprayed, the spray is focussed on the plant rows on top of the bed and, the amount of spray volume is automatically adjusted to the growth stage of the strawberries.

Fig. 1. CDS sprayer in strawberry (left) with adapted air sleeve and nozzle orientation to focus on strawberry plant rows on top of each bed (right).

To show the differences between a CDS-sprayer and a standard air-assisted application technique spray deposition measurements were done in two different crop growth stages; 14 days after planting (BBCH 19) and in full production stage (BBCH 73) of a strawberry crop (31 July 2014; Fig. 3). The strawberry crop had a Leaf Area Index (LAI) of resp. 0.3 and 0.6 m^2 leaf area per m^2 ground surface area, with ground coverage areas in the plant row of resp. 20% and 30%

for the two growth stages. Spray deposition was assessed spraying a strawberry field for 50 m length and three beds wide (4.5 m) with a fluorescent tracer (Brilliant Sulpho Flavine 0.5 g L^{-1}) and Agral Gold (0.075 mL L^{-1}) to mimic a standard spray solution. Spray deposition samples were taken to obtain information on crop spray deposition by cutting six plants (three plants from two rows) and ground deposition on collectors. Samples were taken from the strawberry leaves, the flowers and the fruits, and on soil surface in between and underneath the crop on top of the bed and in the paths in between the beds. Collector (Technofil TF-290, 10 × 100cm on top of canopy and 10 cm × 50 cm on soil surface) layout is schematically presented in Fig. 4. The grower's standard sprayer was a 24 m Mazotti/Rau air-assisted sleeve boom sprayer equipped with TeeJet DG80015 flat fan nozzles (3 bar spray pressure) at 25 cm nozzle spacing. Applied spray volume of the standard air-assisted sprayer and maximum spray volume of the CDS sprayer was 350 L ha^{-1}, both having a forward speed of 5 km h^{-1}. Both sprayers used full air in spraying the different growth stages, as is very common in spraying strawberries in the Netherlands.

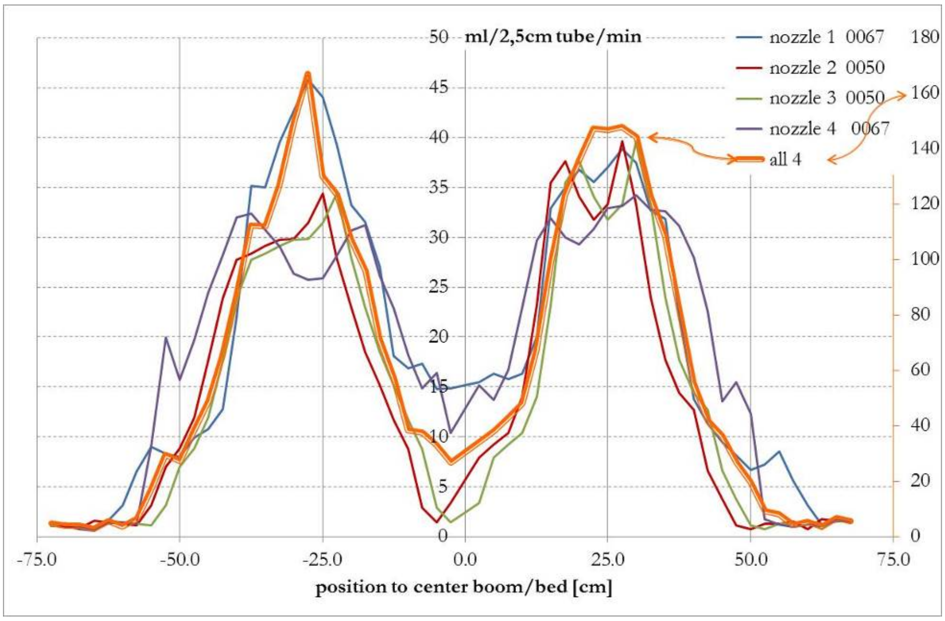

Fig. 2. Liquid distribution on patternator for angled nozzle bodies (2 *2) directed to strawberry plant rows at 0.25 m from the centre of a 1.20 m bed for four individual nozzles and all four together.

Fig. 3. Plant growth stages at moment of spray deposition measurements 14 days after planting (left; BBCH 19) and at full production (right; BBCH 73).

In the laboratory the crop leaves and collectors were washed with deionised water and the solution measured with a fluorimeter (Perkin Elmer LS55; λ_{ex}=450 nm en λ_{em}=500 nm) to quantify BSF concentration. Of the washed leaves the surface area was measured using a Licor surface area meter. From the quantified BSF concentrations the deposition on leaf tissue and collectors was calculated in µL cm^{-2} leaf or collector area and as percentage of applied volume rate.

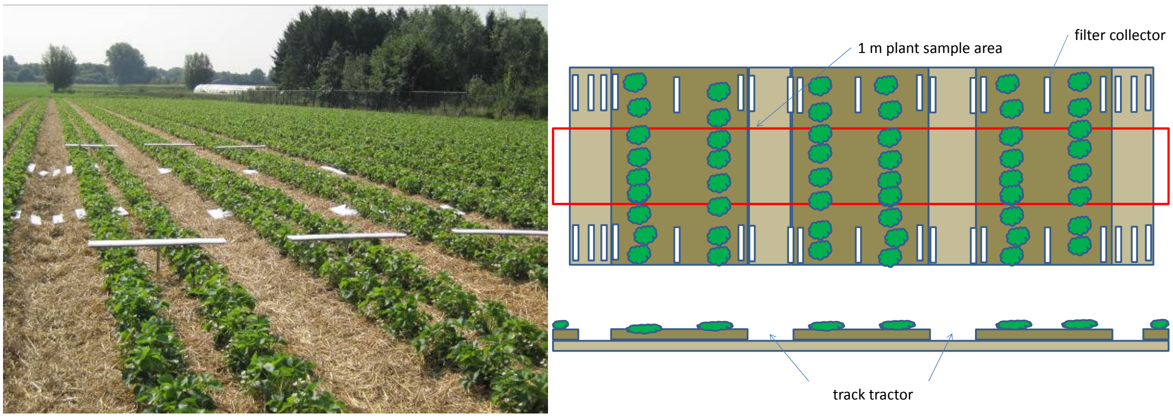

Fig. 4. Field lay-out (left) and schematic presentation (right) of collector positions and area for sampling strawberry plants during spray deposition measurement.

Results

Emission reduction

In both growth stages spray deposition on top of the strawberry bed was 17–25% higher for the CDS spray technique, the Sensispray-Horti sprayer, than for the standard spray technique (Table 1). Loss to soil surface underneath the crop on top of the bed was at growth stages BBCH 19 and 73 for the Sensispray-Horti higher than of the standard air-assisted sprayer. On the ground area on the beds in between the plant rows spray deposition was for both growth stages 50% lower for the Sensispray-Horti compared to the standard air-assisted sprayer. On the paths in between the beds spray deposition was for both growth stages 40% lower for the Sensispray-Horti than for the standard air-assisted sprayer. At early growth stage (BBCH 19) total spray deposition on soil surface was for the Sensispray-Horti 19% lower than for the standard air-assisted sprayer. At full production (BBCH 73) spray deposition on soil surface was for the Sensispray-Horti 30% lower than for the standard sprayer. These lower spray deposits on soil surface reduce the risk for leaching to ground water and through drainage to surface water with 19% to 30% for the Sensispray-Horti compared to the standard air-assisted sprayer used.

Spray deposition

In both growth stages spray deposition on the strawberry leaves was higher for the Sensispray-Horti than for the standard air-assisted spray technique (Table 2). In the early growth stage (BBCH 19) spray deposition on the strawberry leaves was 28% higher for the Sensispray-Horti than for the standard air-assisted sprayer (resp. 1.7 and 1.3 μL cm^{-2}) whereas applied spray volume was about 40% lower. At full production of the strawberries (BBCH 73) spray deposition at the strawberry leaves was 15% higher for the Sensispray-Horti (resp. 1.2 and 1.0 μL cm^{-2}) with also 40% less applied spray volume.

Use reduction

In both growth stages spray deposition on the strawberry leaves was in the 2013 measurements (Michielsen *et al*., 2013) higher for the Sensispray-Horti than for the standard air-assisted spray technique. At early growth stage (BBCH 19) of the strawberry crop spray volume based on the Greenseeker sensor was 140 L ha^{-1} whereas the standard spray technique applied 350 L ha^{-1}, resulting in a 54% use reduction of PPP. At full production growth stage (BBCH 73) spray volume was 230 L ha^{-1} applied to the beds, showing a use reduction of 37%. Including the non-sprayed path areas, use reductions were respectively 62% and 38%. On average for the crop growth season of strawberries the reduction in PPP use on the beds was 38% and including non-sprayed paths 49%. Use reduction (in practice) - at a 5 ha strawberries field a part of the spray applications were performed with the Sensispray-Horti. No visible differences in disease infection were detected. The reduction in applied spray volume of the Sensispray-Horti was 36–57% and on average 49% for the whole growing season.

Table 1. *Spray deposition (µ L/cm²) and (% of applied volume ha⁻¹) on top and on ground at different places of a standard air-assisted sprayer and a CDS sprayer at two growth stages (BBCH) in strawberry*

BBCH stage	technique	standard				CDS sprayer			
	position	top	bed		path	top	bed		path
			under plant	between plant rows	between beds		under plant	between plant rows	between beds
19	Dep [µL cm^{-2}]	2.95	2.15	3.32	2.54	3.45	4.68	1.58	1.43
	P [%]	74	54	83	64	86	117	39	36
73	Dep [µL cm^{-2}]	2.84	1.79	2.98	2.19	3.55	3.04	1.31	1.26
	P [%]	71	45	74	55	89	76	33	32

Table 2. *Spray deposition (*µL cm^{-2}*) and (L at leaf ha^{-1}) of a standard air-assisted sprayer and a CDS sprayer at two growth stages (BBCH) in strawberry*

BBCH	technique	standard				CDS sprayer			
stage	bed	1	2	3	mean	1	2	3	mean
19	µL cm^{-2}	1.26	1.27	1.41	1.31	1.71	1.62	1.71	1.68
	L at leaf ha^{-1}	38	38	42	39	51	49	51	50
73	µL cm^{-2}	1.08	1.04	0.98	1.03	1.24	1.17	1.15	1.19
	L at leaf ha^{-1}	65	62	59	62	75	70	69	71

Fruits were sampled by the grower in order to determine the risk of exceeding MRL thresholds of the picked strawberries because of the higher spray deposition with the use of the Sensispray-Horti. Because of increased residue values (but within limits) it was decided to lower the advised tank concentration of the used PPPs with 25% in order to be on the safe side. This resulted in no recorded difference in disease occurrence in the strawberries picked from the CDS sprayed fields compared to the standard air-assisted sprayed fields.

Discussion

Angling of the air sleeve and nozzles towards the crop rows on the bed improved spray deposition compared to a horizontal spray boom and nozzle orientation. In both growth stages spray deposition on the leaves was for the CDS spray technique 15–25% higher compared to the standard air-assisted spray application. Loss to soil surface on top of the bed and on the paths in between the beds was for the CDS sprayer lower than for the standard air-assisted sprayer. Spray deposition above the crop rows was for the CDS sprayer higher than of the standard air-assisted spray application. Higher spray deposition on the crop canopy and the fruits implicitly means a higher risk for exceeding residue limits on the picked fruits and therefor in practice advised dose of the PPP were lowered 25% by the grower. A safe product was therefore delivered to the market with no difference in disease development compared to the standard air-assisted spray application. Use reduction of PPP with the CDS sprayer could be proven based on increased spray deposition and therefore dose reduction and applying only on the plant area.

In 2015 the 4.5 m working width prototype version is adapted to a 15 m boom CDS sprayer and will be used further in practice. This development is perspective for use in other bed grown crops which will be addressed in future.

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