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Emission reduction in orchards by improved spray deposition and increased spray drift reduction of multiple row sprayers

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Summary

The use of multiple row orchard sprayers is increasing in the Netherlands. These type of sprayers reduce labour costs and improve pest and disease control. The latter because less time is needed to spray an orchard compared to standard axial fan and cross flow fan sprayers. Timeliness is higher and anticipation to weather conditions and disease development improves when using multiple row sprayers. It is assumed that multiple row sprayers could reduce spray drift significantly. This is due to the spraying system that sprays tree rows from both sides at the same time, in contrast to standard orchard sprayers that spray the tree row only from one side. In a series of experiments a comparison was made between the standard cross flow orchard sprayer (Munckhof) and a three row sprayer (KWH). Several nozzle types and settings for air assistance were included in the experimental set up. The spray drift measurements were conducted in the dormant leaf stage and in the full leaf stage of the apple trees. From the experiments, it could be concluded that in the dormant stage spray drift reduction of the KWH three row orchard sprayer equipped with Albuz ATR Lilac nozzles was 50% when compared to the Munckhof cross-flow fan sprayer equipped with the same nozzle and spray pressure and a 3 m crop-free buffer zone. Spray drift reduction increased to 81% in the full leaf stage. The KWH three row orchard sprayer equipped with the Albuz TVI 80015 venturi nozzle resulted in spray drift reductions of 91% in the dormant and 98.6% in the full leaf stage. Using the three row KWH variable air assistance system (VLOS) in combination with the TVI80015 nozzles resulted in a spray drift reduction of 96% in the dormant and 95% in the full leaf stage. Similar effects were found for airborne spray drift. It is therefore advised to setup additional spray drift reduction classes of 97.5% and 99% in the spray drift reduction classification system. Further research is needed to assess spray deposition in the tree canopy and biological efficacy of multiple row orchard sprayers.

Key words: Orchard sprayer, spray drift reduction, air assistance, nozzle type

Introduction

The reduction of the emission of plant protection products (PPP) to the environment is an important issue when applying agrochemicals in fruit growing in the Netherlands. Spray free and crop free buffer zones were introduced, to minimize the risk of mainly spray drift (Water

Pollution Act, Plant Protection Act). New legislation is set into force, in which it is specified that fruit growers have to achieve 90% drift reduction compared to standard spray applications with a cross flow sprayer or axial fan sprayer. At this moment, several drift mitigation measures for fruit growing are accepted by water control authorities; e.g. crop free buffer zone of 9 m, windbreaks (hedgerows), tunnel spraying and specific coarse droplet applications. However, the evaluation of the latest drift figures in orchard spraying in the Netherlands, and measurements of surface water quality parameters show that the current legislation and measures are insufficient to achieve the objectives and could also have implications for approval of pesticides in fruit growing.

New strategies have to be developed to retain chemicals for crop protection and a clean environment. Latest developments showed great perspectives for multiple row sprayers. The use of these types of sprayers has increased dramatically in the Netherlands in the recent years (Wenneker *et al*., 2012). This is predominantly because they require less time to spray an area, and therefore timeliness is higher and anticipation to weather conditions and disease development is better. Therefore, the efficiency of multiple row orchard sprayers is higher than conventional ones for pest and disease control, and reduce costs for the farmer. It is assumed that multiple row sprayers could significantly reduce spray drift. Due to the spraying system that sprays tree rows from both sides at the same time, in contrast to standard orchard sprayers that spray the tree rows only from one side.

Recently, spray drift has become an important issue of social debate. Residents and bystanders of orchards are raising questions about spray applications and possible health hazards. Reducing spray drift could contribute positively in this debate and the public concerns about orchard sprayings.

In this paper the results are presented about the possibilities to increase emission reduction in orchard spraying via improved spray deposition (and as a result a lower dose rate) and spray drift reduction of multiple row sprayers.

Materials and Methods

Experimental set up

Field spray drift measurements from the outer 24 m (eight rows of trees) at the downwind side were performed in an apple orchard (Elstar), using Brilliant Sulpho Flavine (BSF) as a tracer. Spray drift deposition on the ground was measured on a grass strip next to the orchard up to 25 m from the last tree row. Filter collectors (Technofil TF-290) of 0.50 m × 0.10 m in a continuous line from 3 m to 15 m and 1.00 m × 0.10 m collectors at 20 m and 25 m distance of the last tree row were used. Airborne spray drift was measured at 7.5 m distance from the last tree row on a mast of 10 m height using ball shaped collectors (Siebauer Abtrifftkollektoren) every metre.

In cooperation with the sprayer manufacturer KWH, a multiple (three) row sprayer was constructed and tested for its drift reducing capacities. This sprayer is capable of adapting left- and right- hand side air settings separately based on an ultrasonic anemometer placed on top of the sprayer (VLOS system). The anemometer wind speed and wind direction signal is compensated for driving direction and driving speed. The air amount on the outside air spouts can be switched off manually to prevent blowing recirculated spray liquid sucked by the fan through the air ducts to the outside of the orchard when spraying the outside tree row. Using GPS on the sprayer on the downwind outside three rows of the orchard the air amount is set to maximum to the inside of the orchard and one third to the outside, second path of three tree rows is set to two thirds of maximum to the outside and the third path of three rows as standard air to the outside of the orchard. This is schematically presented in Fig. 1. It is expected that the variation in air amount at the outside tree rows of the orchard will minimise spray drift as a minimal amount of air is passing through the tree canopy because of the sprayer air settings.

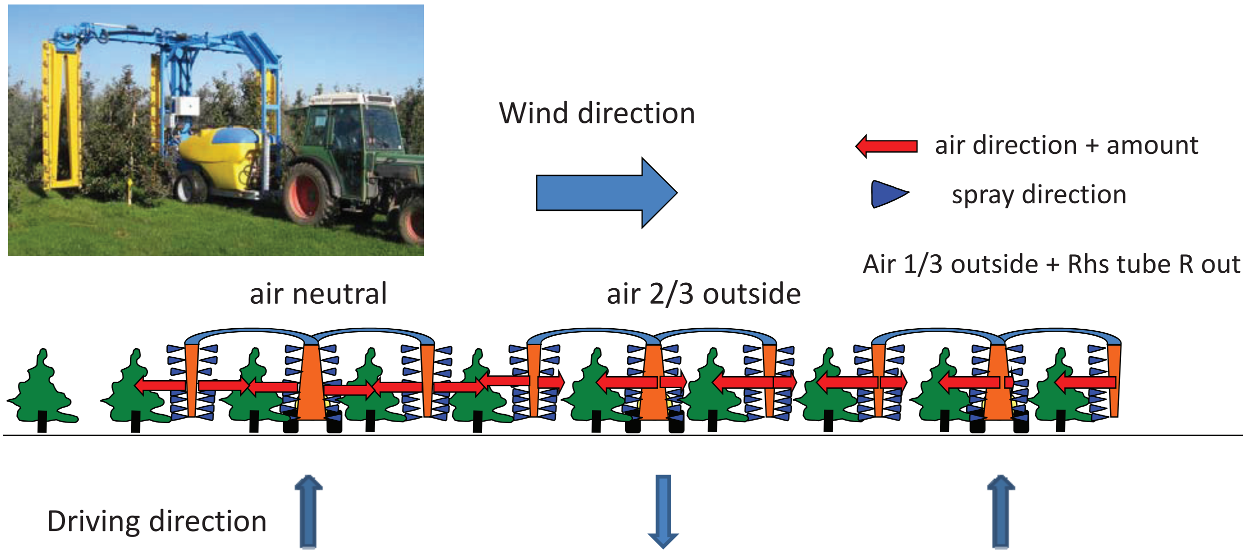

Fig 1. Schematic layout of air setting of the KWH three row sprayer with automatic adjustable air settings (VLOS).

Treatments

In this experiment different treatments were compared:

Reference sprayer (Munckhof)

1. standard – conventional cross-flow fan sprayer (Munckhof); Albuz ATR lilac at 7 bar spray pressure (Fine spray quality; Southcombe *et al*., 1997). [Mun-ATR Lilac].
2. standard – conventional cross-flow fan sprayer; Albuz TVI 80025 at 7 bar spray pressure (Coarse spray quality – 95% drift reducing nozzle type) – and one sided spraying of the outside row (outside path spraying outside to inside only, other paths two-sided). [Mun-TVI 80.025].

Multiple (three) row orchard sprayer (KWH)

3. equipped with Albuz ATR Lilac nozzles (as standard). [KWH-ATR lilac].
4. equipped with 90% drift reducing TVI 80015 nozzles. [KWH-TVI 80.015].
5. equipped with 90% drift reducing TVI 80015 nozzles and manual setting of the air in the outer two swaths. [KWH-manual-variable].
6. equipped with 90% drift reducing TVI 80015 nozzles and reduced air assistance (400 rpm pto). [KWH-400 rpm].
7. equipped with 90% drift reducing TVI 80015 nozzles variable air assistance system (VLOS) controlled by an anemometer on the sprayer. [KWH-VLOS].

Also, for the multiple row orchard sprayer spraying pressure was 7 bar for each treatment. All measurements were performed during a) full leaf stage and b) dormant leaf stage of the fruit trees. Air settings for the reference sprayer (Munckhof) were low in the dormant and high in the full leaf situation.

Results

Drift deposition

High spray drift reductions were achieved with the different settings of the KWH three row orchard sprayer. Tree rows sprayed from two sides at the same time resulted in higher spray drift reduction levels compared to single-sided tree row applications. Spray drift reduction of the different settings of the KWH three row orchard sprayer relative to the reference Munckhof cross-flow fan sprayer are presented (Table 1) for the surface water area next to the orchard (bank to bank) at 3–7 m and for the water surface at 4.5–5.5 m distance from the last tree row.

In the dormant stage spray drift reduction of the KWH three row orchard sprayer equipped with Albuz ATR Lilac nozzles was 50% when compared to the Munckhof cross-flow fan sprayer equipped with the same nozzle and spray pressure and a 3 m crop-free buffer zone. Spray drift reduction increased to 81% in the full leaf stage. The KWH three row orchard sprayer equipped with the Albuz TVI 80015 venturi nozzle resulted in spray drift reductions of 91% in the dormant and of 98.6% in the full leaf stage. Using the three row KWH variable air assistance system (VLOS) in combination with the TVI80015 nozzles resulted in a spray drift reduction of 96% in the dormant tree and 95% in the full leaf stage.

Table 1. *Spray drift reduction of KWH three row orchard sprayer settings at surface water (3–7 m) and water surface (4.5–5.5 m) in the dormant and full leaf stage*

	Dormant tree stage		Full leaf stage	
Technique	3–7 m	4½–5½ m	3–7 m	4½–5½ m
KWH ATR Lilac	46	50	80	81
KWH TVI 80.015	88	91	98.3	98.6
KWH manual #	97.8	98.1	98.0	98.5
KWH 400 rpm #	94.9	96.1	99.2	99.4
KWH VLOS #	94.5	95.8	94.2	95.0

#: TVI 80.015 nozzles.

In Figs 3 and 4 the spray drift deposition curves are shown for the dormant and full leaf stages, respectively. Highest drift deposition is observed with the standard cross flow sprayer and Albuz lilac nozzles. Significantly lower depositions were measured with these nozzles mounted on the three row sprayer. Low drift depositions were observed with the drift reducing nozzles. Again highest drift depositions with the standard cross flow sprayer, and lowest with the multiple row sprayer. Figs 5 and 6 show that very high drift reductions can be achieved with the three row sprayer equipped with drift reducing nozzles at relatively short distances from the last tree row. In contrast to the standard cross flow sprayer where more distance is needed to obtain the maximal drift reducing capacity of the drift reducing nozzle.

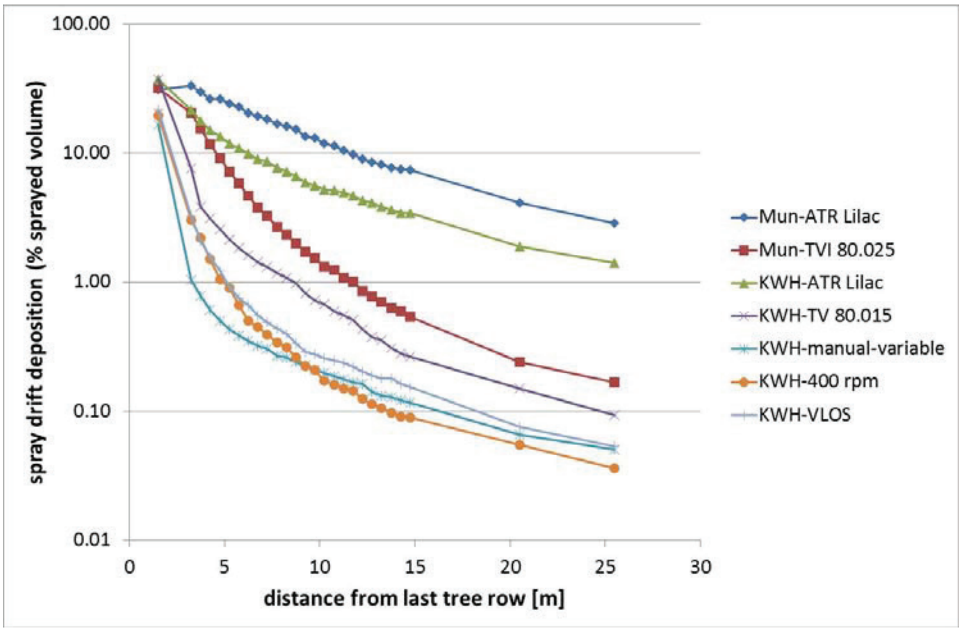

Fig. 2. Spray drift deposition – dormant tree situation.

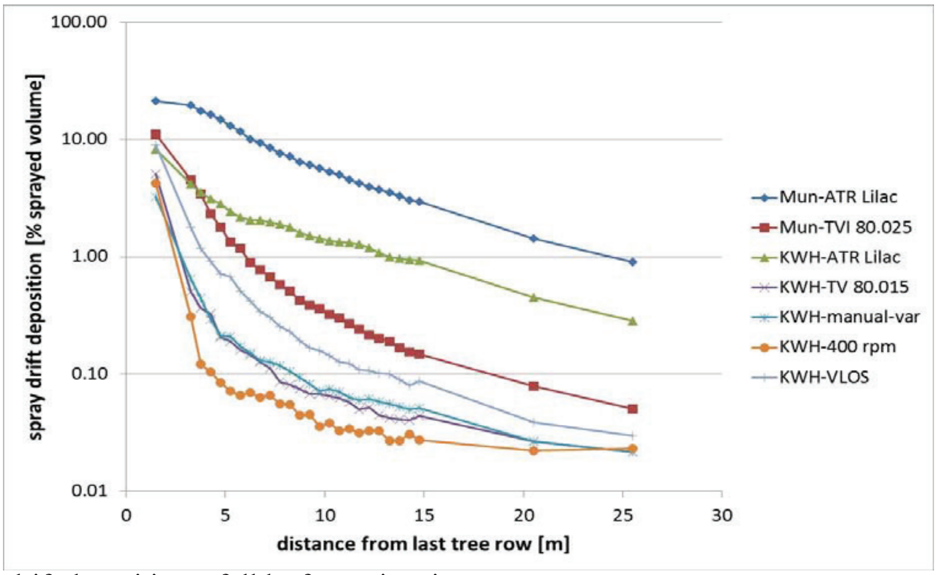

Fig. 3. Spray drift deposition – full leaf tree situation.

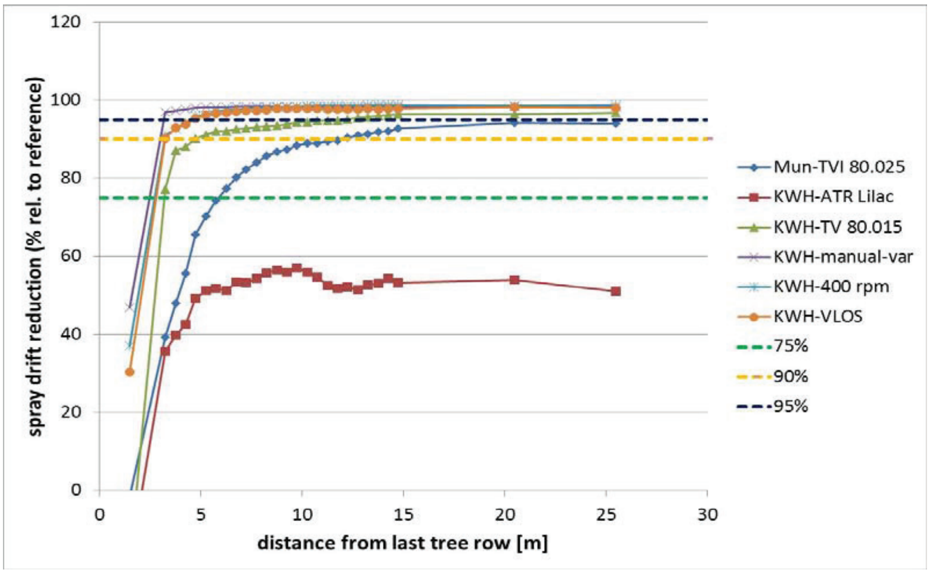

Fig. 4. Spray drift reduction – dormant tree situation.

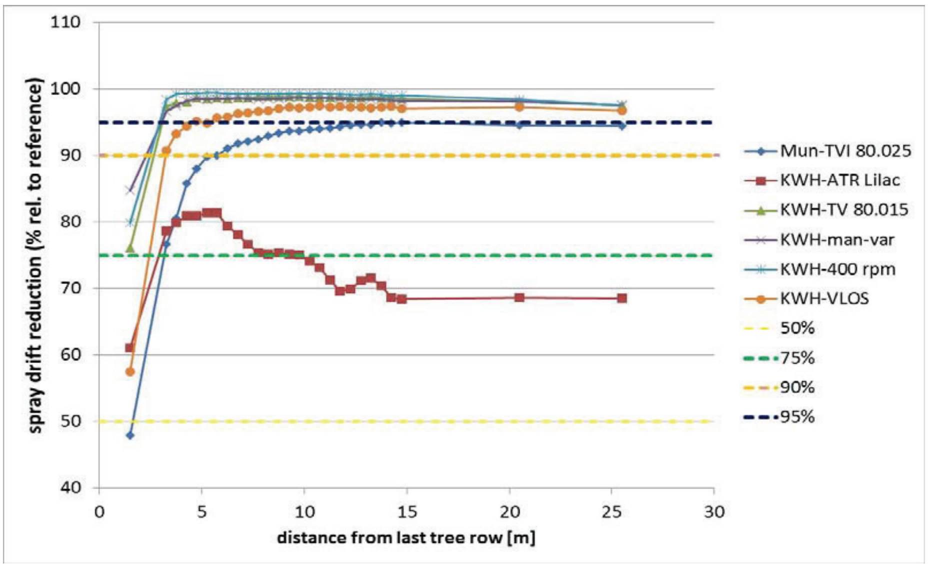

Fig. 5. Spray drift reduction – full leaf tree situation.

Airborne spray drift

The airborne spray drift in the dormant and full leaf stage of the orchard is presented in Figs 6 and 7, respectively. Airborne drift in the dormant situation is significantly higher than in the full leaf situation. A clear drift reducing effect is present when low drift nozzles are used, either on the standard cross flow fan sprayer or the KWH multiple row sprayer. With special emphasis to the Albuz lilac nozzles, which generate most air borne drift, very high drift figures are found compared to spray drift deposition at the same measuring distance from the last tree row. Peak values of airborne spray drift are found at 1–3 m height.

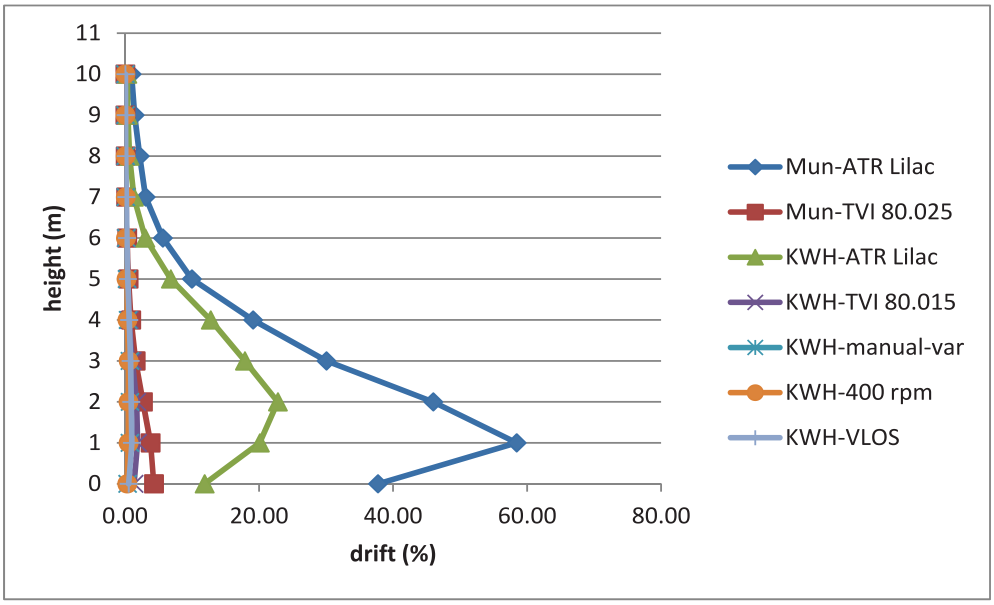

Fig. 6. Airborne spray drift on different heights (0–10 m) at 7.5 m from the last tree row – dormant tree situation.

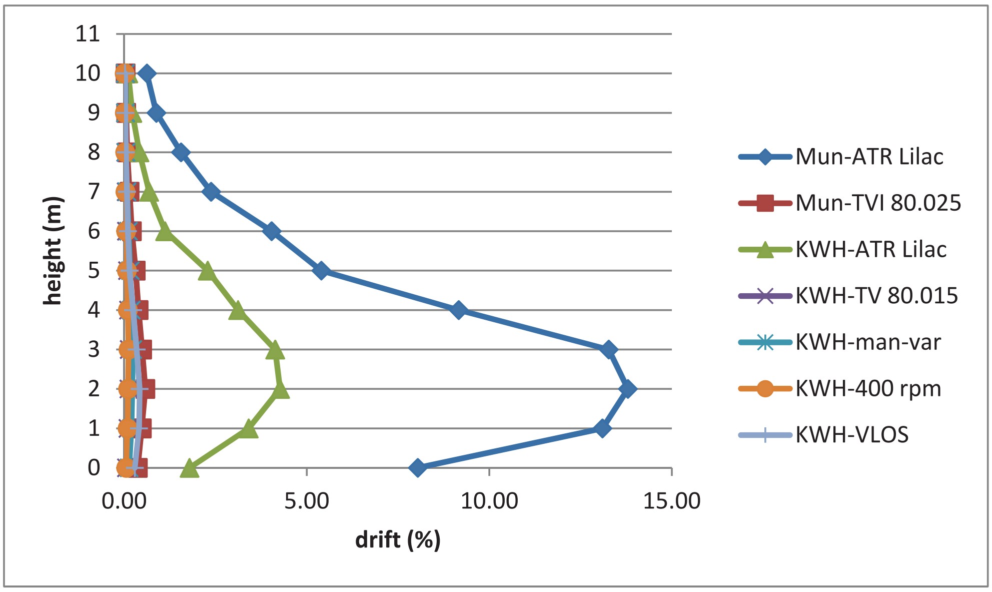

Fig. 7. Airborne spray drift on different heights (0–10m) at 7.5 m from the last tree row – full leaf tree situation.

Discussion

Spray drift from pesticide applications is a major concern in the Netherlands, especially spray drift into water courses. So far, several drift reducing measures have been accepted by water quality control organizations and the Board for the Authorization of Pesticides (CTGB), e.g. presence of a windbreak, the use of a tunnel sprayer or drift reducing venturi type nozzles with one sided spraying of the outer tree row (Wenneker *et al*., 2005). With reduced air assistance and low drift nozzles it is possible to achieve very high drift reductions, even at short distances from the orchard. Recently, a nozzle classification system for drift reduction in orchard spraying has been developed (Zande *et al*., 2012). Some of the drift reduction methods have marked disadvantages for the fruit grower, such as high investment costs (tunnel sprayer) or the loss of cropping area (windbreak). More advanced systems, such as the CASA system showed the potential of sprayer models equipped with wind sensor and GPS navigation system which enables real time adjustment of application parameters such as airflow and spray quality to reduce the negative environmental impact of spray applications in orchards (Doruchowski *et al*., 2012). Prototypes of Canopy Density Sprayers are recently introduced at a practical farm level in the Netherlands (Nieuwenhuizen & Van de Zande, 2012).

The results presented in this paper show that very high drift reductions can be achieved by a multiple row sprayer equipped with drift reducing nozzles. It is therefore advised to setup additional spray drift reduction classes of 97.5% and 99% in the spray drift reduction classification system. The evaluation of the latest drift figures in orchard spraying in the Netherlands, and measurements of surface water quality parameters show that the current legislation and measures are insufficient. This could also have implications for approval of pesticides in fruit growing. To meet the national and European objectives regarding surface water quality also a reduction of chemical input is required. Further research, therefore, is required to assess spray deposition in the tree canopy when spraying with multiple row sprayers. It is assumed that spray depositions are improved with these types of sprayers and dose can be reduced accordingly, without reducing biological efficacy.

Airborne spray drift can be very high when using Albuz ATR lilac (Fine Spray quality). These airborne drift values are significantly higher than spray depositions at soil surface at the same distance, as also found in earlier experiments (Michielsen *et al*., 2005). The use of low drift nozzles and a multiple row sprayer results in very low airborne drift figures. This implies that reducing drift to the soil and surface water would also reduce drift exposure to residents and bystanders.

Acknowledgements

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