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Towards efficient sprayer cleaning in the field and minimum point source pollution

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Summary

To be able to give guidance to sprayer manufacturers how to develop sprayers that are safe to the environment, legislation needs to be clear and concise. The new European frame work directive on sustainable use of pesticides has defined some broad goals and measures that member states will fill in with national legislations. A missing link, so far, has been to see how sprayers in general fulfil the more specific demands as given in France and Denmark – and in this way to get an indication if the demands are specific and robust enough to ensure that environmental advantages are achieved. A relevant question is how the legislators can check that new sprayer types and sprayers in use fulfil the requirements – what tools and tests could be relevant?

This paper describes a method for testing efficacy of sprayer cleaning and results from triple rinsing of seven sprayers. The test includes measurements of residue concentrations at various places on sprayers after rinsing with water, and the volume that can be drained from the sprayer after emptying the sprayer as much as possible through nozzles.

A concentration less than 1 or 2% of the original tank mix concentration (as defined by France and Denmark) measured at the nozzles does not guarantee that there is no higher residue concentrations elsewhere in the liquid system. Filter houses and hoses for filling or draining the main tank often contain residue concentrations higher than what is measured at the nozzles after cleaning. Some sprayers had 10–15% of the original tank mix concentration at drainable valves after cleaning. On three sprayers 12,5 L–12,6 L could be drained from the tank emptying valve – all with residue concentrations higher than prescribed from France and Denmark.

The results described in this paper, suggest that new European and International standards should include test methods and requirements for a maximum residue concentration anywhere in the sprayer, as well as a maximum for the "drainable" residue fraction.

Key words: Residue volume, residue concentration, drainable residue, European Standard, point source contamination, pesticides, sprayer rinsing, orchard sprayers, boom sprayers, continuous cleaning

Introduction

In their overview of the risk of water contamination by plant protection products during pre- and post-treatment operations Jaeken & Debaer (2005) found, that according to the studies included in the overview 40–90% of surface water contamination is attributed to direct losses – point sources. Further it is revealed that these point sources are mainly linked to the filling and cleaning area on the farm. In Europe the need for safe and efficient sprayer cleaning has been stressed through the establishing of the European Project TOPPS (Training the Operators to prevent Pollution from Point Sources (Balsari & Marucco, 2007)). At the end of the TOPPS project it was concluded that "There is insufficient understanding of the residual volume of spray liquid remaining in the sprayer after termination of spraying". Further it is assumed this is due to a current lack of focus in the information and advice to farmers. "Information on the residual volumes today is not generally an integral part of the technical information provided with a new sprayer."(Roettele, 2008).

Thus it is important that the sprayer is cleaned efficiently in the field and as little pesticide as possible remains in the sprayer when re-entering the farm whether the sprayer is to be left in a barn or, for example, over a biobed. Where Debaer *et al*. (2008) in their work deal with total residue and the impact on farm water treatment systems, this paper deals with drainable residue volume and concentration as key factors for minimising any potential point source pollution – and as a step forward towards getting a better understanding of the residual volume. The aim is to better define future requirements for ensuring minimum point source contamination in the field and on the farm – furthermore the test work presented in this report aims to reveal if the tested sprayers can be cleaned as efficiently as French and Danish legislation expects (dilution down to relatively 1% and 2% of original tank mix conc.) (Ministere de l'agriculture (2006) and Miljøstyrelsen (2009)).

Materials and Methods

In Denmark one field sprayer (T1, trailed 4000 L, 24 m) has been tested by Betterspraying aps and in Germany three field sprayers (lift mounted L 1800 L 24 m, trailed T2 4200 L 24 m, and trailed T3 5000 L, 30 m) and three orchard sprayers of 600 O1, 1000 O2 and 1500 L O3 have been tested in a joint venture by the JKI and Betterspraying . The tests in Germany were initiated by the ISO working group for developing standards on cleaning of sprayers in order to get a deeper understanding of the cleaning procedure as a way to minimise point source pollution (in the past the goal of sprayer cleaning has primarily been to minimise crop damage).

The sprayers were tested using the following method: With the liquid system full of water and 100 L of water in the main tank fluorescent dye (pre dissolved natrium fluoresceine) concentration 0,00005% is added to the main tank. The tracer dye is added via the main tank filling hole. All liquid system functions are activated. After circulating the dye to all parts of the sprayer, a reference-sample is taken from the main tank.

The sprayer is then emptied as much as possible by spraying as in normal practise. The pump has been kept running till only air and no more liquid is coming from the nozzles, as a way to minimise the residual in the sprayer.

Now the cleaning procedure starts – all tested sprayers have been rinsed with the contents of the cleaning tank mounted on the sprayer (minimum 10% of main tank capacity), following the triple rinse method, as described by Balsari *et al*. (2008): 3 × 1/3 of water is introduced into the sprayer, circulated in the system and sprayed out. Towards the end of emptying the last lot of rinsing water, a sample is taken from the last nozzle at one of the far ends of the boom. After stopping the pump further samples are taken from the residues in the tank and filter housings by opening the tank emptying valve and filter housings and collecting the liquid. Where present, valves on filling lines have also been opened and samples taken.

The drainable residues are collected and the volume is measured. Drainable residues are typically found at the locations just mentioned: filter housings and at water emptying- and filling valves.

All samples are analysed with a fluorimeter. The reference tank samples are used to calibrate the fluorimeter - reading 100 (%).

Results

The measured concentration of the residues let out from tank sump through the emptying valve and samples collected from the nozzles at the far end of the booms - after triple cleaning - are shown in Fig. 1. "Other "drainable refers to measurements of concentration in filter-housings or filling valve showing the highest value found for each sprayer.

For O1 and O2 there were no measurements of "other drainable".

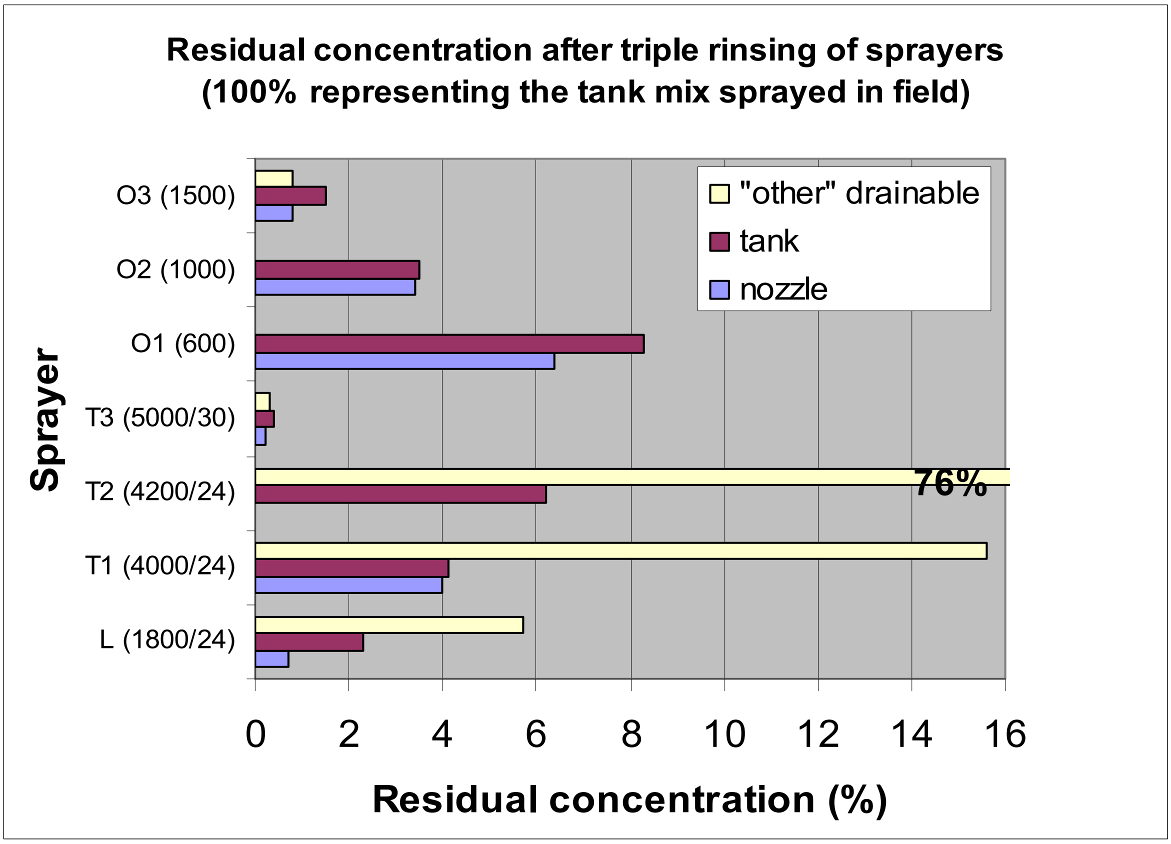

Fig. 1. Concentration in the sprayer residuals at various places on sprayers after triple rinsing – relative to an original tank mix set to 100%. "Other" drainable refers to concentration in filter housing or filling valve – showing the highest value found for the sprayer. L is lift mounted, T is trailer sprayer and O is orchard sprayer. Tank volume (l) and boom size (m) in brackets. For O1 and O2 there were no "Other" drainable measurements. One nozzle residual was 0 (T2). The highest residual was 76% (T2 "other" drainable).

Only one sprayer – T3, the biggest trailer sprayer in the trial with 5000 l tank and 30 m boom - is rinsed to a residue concentration level [0,4%] satisfying the French maximum limit of 1%. Regarding the Danish legislative limits also one orchard sprayer, O3, with the biggest tank of 1500 L, shows satisfactory results [1,5%].

For all sprayers, the nozzle samples show a smaller concentration than samples from any other place on the sprayer where samples were taken. For three out of the seven sprayers the highest concentration was found in "other drainable" parts than from the main tank.

The highest residue concentration was found in "other" drainable on T2 where 76% was measured at the water filling valve – the volume measured was 0,6 l.

In Fig. 2 the residue concentration from the main tank is plotted against the number of litres drained from the main tank after emptying the sprayer as much as possible through nozzles. From the main tank two sprayers drain less than 2 litres (1,8 l drained from L and 0,5 l from O3) and both at low concentrations: 1,5% (O3) and 2,3% (L). All trailed field sprayers drain about 12 L alone from the main tank (T1 and T3 12,5 L and T2 126 L), however at very different concentrations, for T1 the concentration is 10,6 % and for the largest sprayer T3 it is 0,4%.

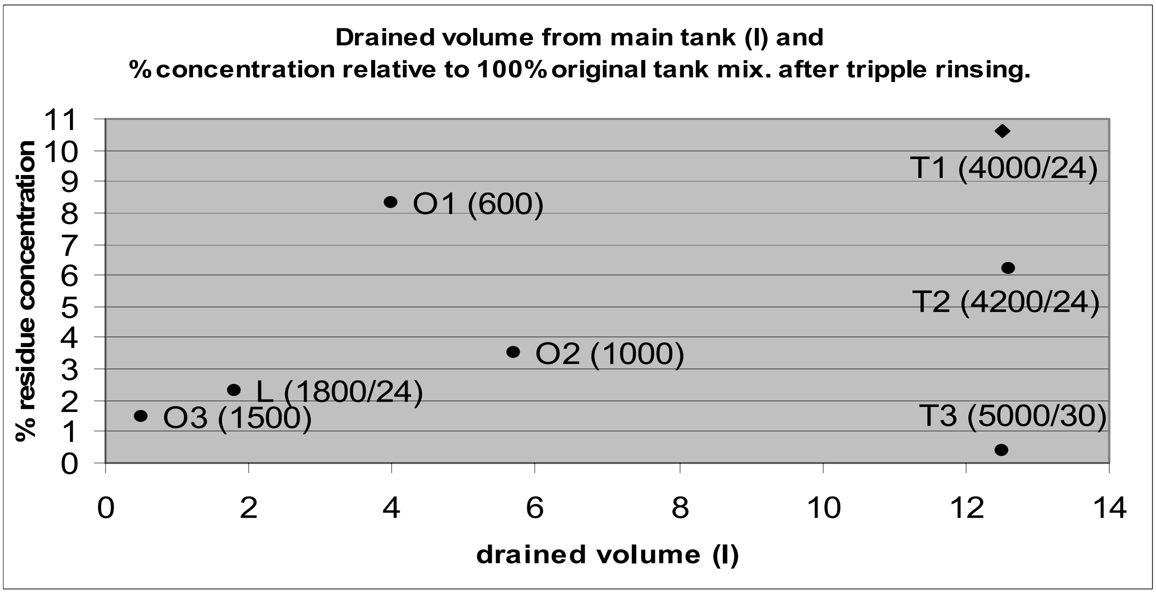

Fig. 2. Residue concentration and quantification of drained volume from sprayers after triple rinsing. Concentration is relative to an original 100% spray mix. L is lift mounted, T is trailer sprayer and O is orchard sprayer. Tank volume (L) and boom size (m) in brackets.

Conclusion

The tests referred to in this paper have been carried out on new sprayers and sprayers in use, hence the results describe state of the art. Working with a selection of sprayers has shown that even for modern sprayers there are great variations, in how well the liquid systems can be cleaned. four out of the seven sprayers had concentrations below 1% at the nozzles after triple rinsing: 0,7% (L), 0% (T), 0,2% (T3) and 0,8% (O3).

If also looking at tank residues and residual concentration in other drainable parts, only two sprayers could present results acceptable to French and Danish legislation. In “other drainable” concentrations up to 15,6%, were found.

Three sprayers – the trailed field sprayers – drained more than 12 L alone from the emptying valve: 12,5 L (T1), 12,5 L (T2) and 12,6 L (T3).

In the relatively small sample of sprayers representing both field and orchard sprayers no trends could be seen regarding residue concentrations based on sprayer typed. Both orchard sprayers and boom- sprayers turned out to include examples of low and high residue concentrations. However from the lift mounted sprayer and the three orchard sprayers less than half the volume (ranging from 0,5 l–5,7 L) of residuals were drained from the main tank when comparing to the three trailer sprayers.

Perspectives

The process of cleaning sprayers in order to minimise point source contamination is new to sprayer designers and manufacturers, to sprayer operators, researchers and authorities. Cleaning equipment and cleaning methods are not yet fully optimised. There is a need for development of clear and simple-to-follow cleaning guidance for new sprayers as well as for sprayers in use.

Traditionally standards concerning sprayer cleaning have been given based on an aim to minimise crop damage when going into a crop sensitive to the previous chemical. For determining total residue volume a sprayer has been considered “empty” when the spray pattern start collapsing at the nozzles or when pressure falls 25%. (ISO 13440:1996, EN 12761–2. 2002 and EN 12761–3. 2004) This definition of “empty” is adequate from an optimum liquid distribution point of view

– but not suitable when the goal is to minimise point source pollution.

Aiming to minimise point source pollution is a totally different approach than optimising for minimum crop damage, thus calling for new key factors like drainable volume (from a sprayer that has been emptied as much as possible by spraying in the field) and concentration of the diluted residues.

New regulations and standards should contain requirements to sprayers as well as define the test procedures that can reveal if the requirements are fulfilled. The test results indicate the need for manufacturers to focus on at least three places on the sprayer apart from the nozzles, where residual volume and concentration can lead to point source pollution: filter housings and filling- and emptying valves.

A possible approach for authorities could be to define a maximum quantity of plant protection product that can be accepted on the ground in the field when draining all drainable volume from at sprayer after cleaning.

A great challenge is no doubt to successfully combine the efforts of minimising both crop damage and point source pollution.

Not mentioned earlier in this paper but yet an other challenge that calls for special attention, when dealing with sprayers as sources for point source pollution, at least in Denmark, is the cleaning of chemical filling devices that are now mandatory to use in DK (EN /ISO 4254-6 2009 in combination with Danish legislation). The method for checking cleaning efficacy described in this paper does not involve the chemical filling device, nor chemical injection devices. This can be considered as a weakness in the methodology and it is strongly suggested that cleaning of chemical filling and chemical injection devices are included in future methodology trials concerning sprayer cleaning to reduce point source contamination.

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