Investigation of spray drift reduction solutions for agriculture

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Introduction

Pesticides are applied to the surface of plants by agricultural sprayers, with spray nozzles which are placed in sprayer boom to spray liquid chemicals. At that moment, blowing side wind or frequent gusts of wind can blow poisonous droplets quite far away (30 m or more). Tepper (2017) states spraying many plant protection products are not recommended at wind speeds higher than 4 m s^{-1}. Droplet drift poses not only environmental problems but also economic ones. Drift potential increases as the proportion of small droplets increases (Stainier et al., 2006). Drift reduction is attempted by various technical and technological means: selecting the optimal spraying speed and spraying time, choosing different nozzle types, changing pressure of spray liquid, using additives (**DRA** – ***drift reduction agents***) that change properties of the spray liquid, installing spray boom vibration absorbers or various technical measures to protect the flow of sprayed droplets from the influence of wind and etc.

Aim of the work: to analyse the efficiency of the new developed two drift reduction agents (DRA) of different active substances; for this purpose, in order to substantiate the most rational DRA, to perform a comparative research to investigate the downwind speed of the DRA solutions in a wind tunnel stand.

Methodology

Trials of experimental DRA (drift reduction agents) development were carried out in 2020 at the Laboratory of Chemical and Biochemical Research for Environmental Technology, Vytautas Magnus University Agriculture Academy, Lithuania.

The chemical compositions of two DRA were based on:

- Calcium dodecylbenzene sulfonate 50%, butanol for DRA1;
- Anionic polymer dispersion 100% for DRA2.

The active ingredients contained in DRA demonstrated a significant effect on the decrease of static surface tension (Table 1).

Table 1. Static surface tension of solutions

Static surface tension γ_s, mN m^{-1}		
DRA1	DRA2	Water
30.5±0.2	30.6±0.2	72.8±0.1

In 2021 at the VMU Agricultural academy the Laboratory for Investigation Technological Processes of Agricultural Machinery using wind tunnel research has been carried by air-injector nozzle (spray angle – 120°, performance – 1.82 l min^{-1} at pressure – 4 bar) (Figure 1). The cross – section of wind tunnel increases from 0.9 × 0.9 m to 1 × 1 m, respectively, and its length reaches 5 m. The stand is equipped with axial air suction fan ML 1004 DT with a ten plastic blades which diameter is 1000 mm, and electric motor (power 15 kW, rated shaft speed 1465 rpm). The Delta VFD-C2000 voltage frequency converter is used to set the speed of the motor. Changing the speed of the motor and fan impeller also changes the air flow (during investigation it was 6 m s^{-1}). The spray liquid was supplied with a Pentair Hypro Shurflo Standard Table Spray 220 VAC. A nozzle was placed at a height of 50 cm above the surface of the liquid collection vessels. On both sides, in the longitudinal direction of the tunnel, the nozzle sprayed the liquid at 85 cm intervals, i.e. the area of the liquid droplets sprayed by the nozzle was 170 cm (when the air flow rate was 0 m s^{-1}). In this case the liquid carried further than 85 cm from the nozzle is considered as spray drift. The nozzle was placed to investigate the effect of side direction air flow on droplet drift – conditions were simulated when spraying in the field when the wind direction is making an angle of 90° with the direction of sprayer movement. A total of 30 L of each DRA solution and water was sprayed. The liquid in each of the 44 flasks was determined and calculated as a percentage. Tests were repeated three times.

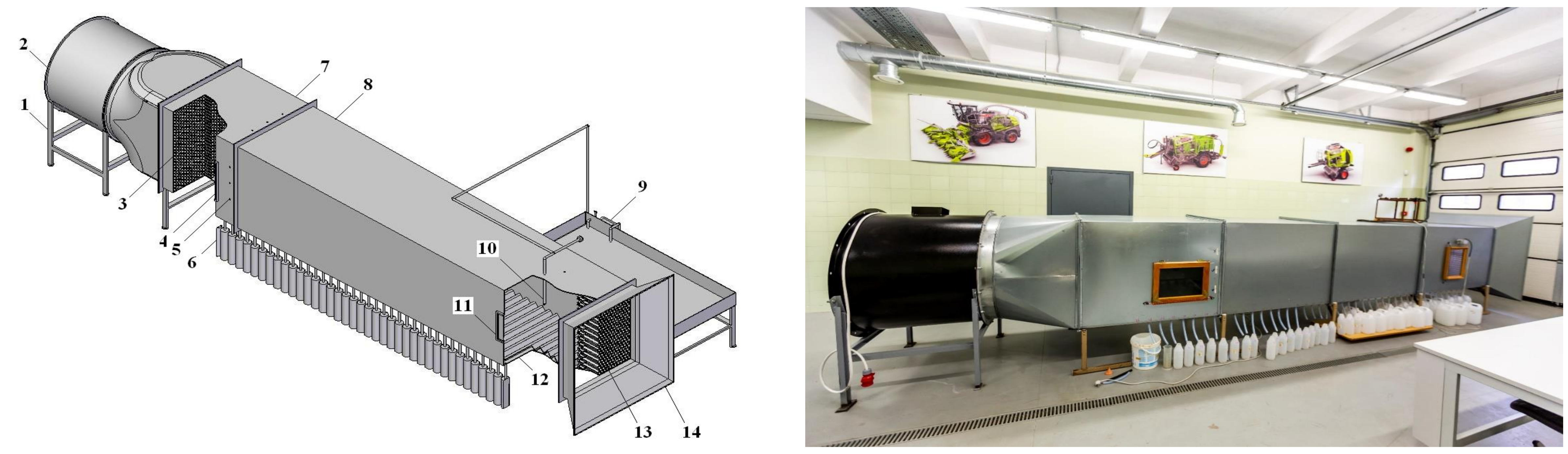

Fig. 1. Test bench (wind tunnel) for spray drift investigation (Bauša et al., 2017): 1, frame; 2, suction fan with electric motor; 3, 13, air flow straighteners; 4, 11, window; 5, air velocity measurement place; 6, flask; 7, connection chamber; 8, investigation chamber; 9, spray supply equipment; 10, nozzle; 12, corrugated tin; 14, air intake section

Results

An open circuit type wind tunnel was used to study the drift from sprayer nozzle under controlled and repeatable environmental and spraying conditions. An air-injector nozzle was tested at wind speed of 6 m s^{-1}. Spray solution drift was found to be dependent on DRA type based on the wind tunnel trial. Water was sprayed as a control (static surface tension of water 72.8 mN m^{-1}).

A comparison of the results obtained DRA1 and DRA2 shows that there is no significant difference between both products (Figures 2 and 3). DRA1 solution was drifted by 11.9 ± 0.1% and DRA2 solution was drifted by 12.3 ± 0.4%, the difference between these products was only about 0.5 percentage unit. Thus, it can be said that they are both effective enough to reduce the drift of sprayed droplets downwind (about 25% compared to the control) when a crosswind speed not exceeding 6 m s^{-1}.

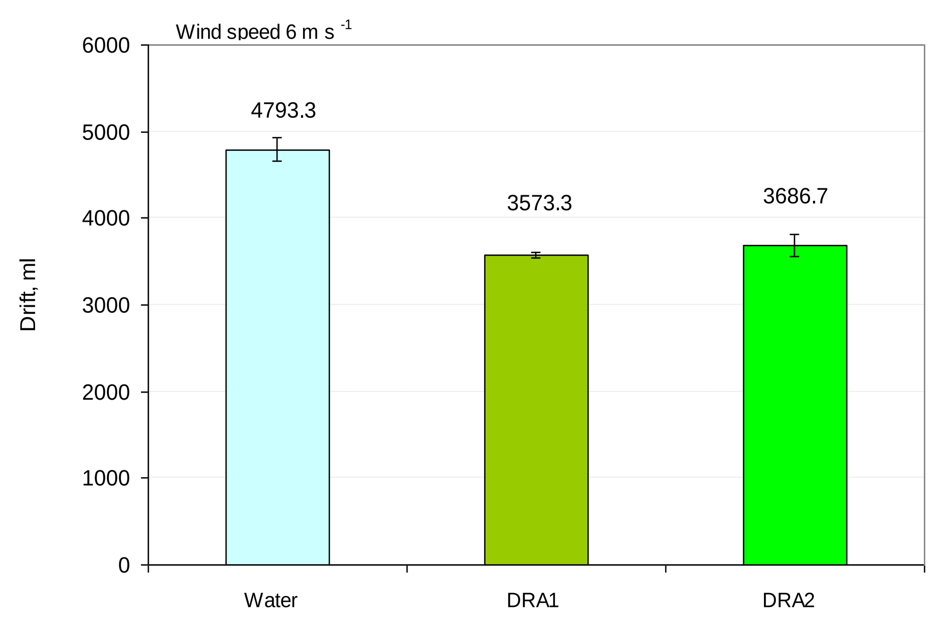

Fig. 2. Spray drift (ml) affected by side wind

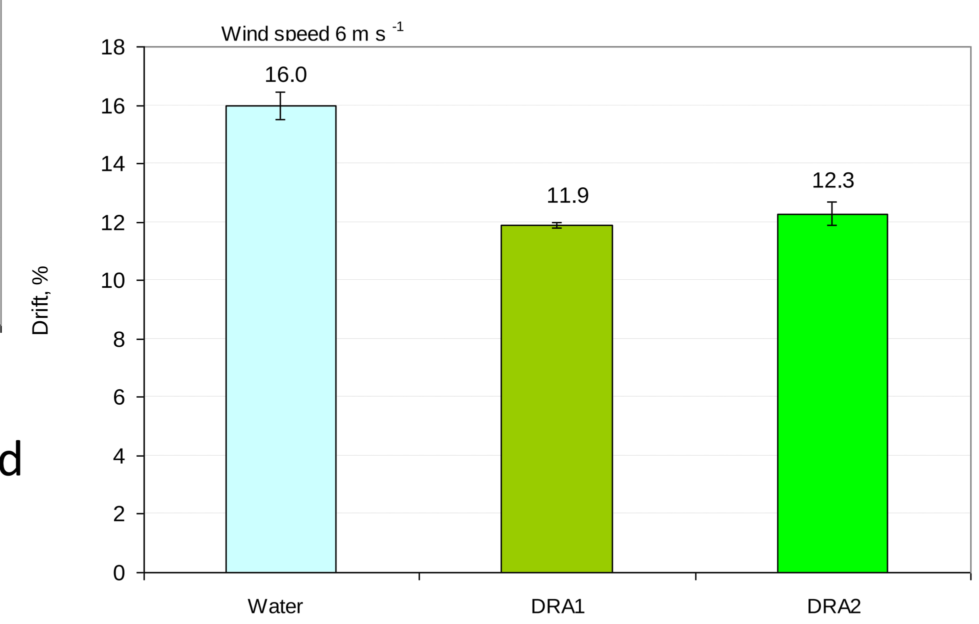

Fig. 3. Spray drift (%) affected by side wind

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Main conclusion

Studies have shown that DRA1 and DRA2 solutions droplets downwind drift was about 25% less than water. Thus, the use of both experimental DRA's will have a positive impact on the environment.