Air flow influence on agricultural sprays: application to a specific vineyard sprayer

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Introduction

Agricultural hydraulic nozzles are generally classified according to mean values of spray droplet diameter, like Dv10, Dv50 (*i.e*. Volume Median Diameter) or Dv90 measured on vertical sprays without any air co-flow. In vineyards, some sprayers deliver sprays that are horizontally oriented, and may be surrounded by an air flow. A previous study showed that median diameter was not affected by nozzle orientation (horizontal versus vertical), but gravity effect was noticeable regarding spatial repartition of droplet diameter and velocity [1]. The objective of this study was to investigate the effects of air flow on horizontal sprays, regarding droplet diameter and droplet velocity.

Materials and Methods

Three different nozzles were used, namely a standard hollow cone nozzle TXA 80 0067 khaki (Teejet, USA), an air-induction hollow cone nozzle TVI 80-0050 violet (Coors Tek Solcera, USA) and an air-induction flat-fan nozzle IDK 90 01 orange (Lechler, Germany). Nozzles were mounted on a vertical boom taken from a vineyard sprayer (Vectis, Tecnoma, France). The injection pressure P of each nozzle was such that the delivered flow rate of water was identical, equals to 0.37 $l.mn^{-1}$ (P = 5.7 bar for the TXA, P = 10 bar for the TVI and P = 2.6 bar the for IDK nozzle).

Two series of measurement were carried out within a plane at a distance x = 40 cm from the nozzle exit, the first one without air flow, the second one with an air flow (maximum velocity of 12 m/s at x = 40 cm). This distance corresponds to the usual spraying distance in vineyards. There was an angle between nozzle axis and air flow axis (parallel to x) of 30 degrees (see Figure 1).

Droplet diameter and one velocity component were measured using a Phase Doppler Particle Analyzer (Dantec, Denmark). The velocity component corresponded to the projection of the droplet velocity vector along the x axis. The measurements were performed at room temperature (T=24°C, relative humidity H = 70%).

Results

Values of Dv10, Dv50 and Dv90 of the three nozzles without and with air flow are presented in Table 1. Values were only slightly changed by air flow addition. This first result shows that nozzle assessment without air is appropriate.

Nozzle Type	TXA @5.7 bar		TVI @10 bar		IDK @2.6 bar	
	Without air	With air	Without air	With air	Without air	With air
DV10 (µm)	73	72	235	214	327	331
DV50 (µm)	121	118	405	385	577	572
DV90 (µm)	173	172	621	583	830	828

Table 1: Dv10, Dv50 and Dv90 measured by PDPA at 40 cm from the nozzle exit.

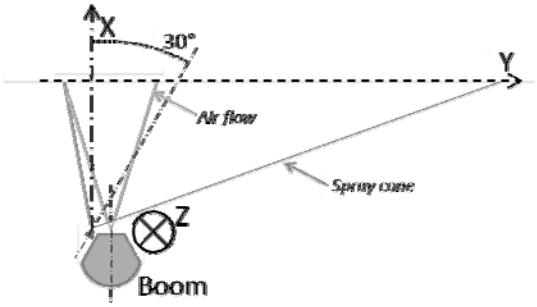

Figure 1: Top view of the Experiment

Profiles of the averaged velocity component (left) and the averaged diameter (right) are presented for the three nozzles with (blue dotted line) and without (red solid line) air flow in Figure 2. Average was calculated on droplets caught for all z values.

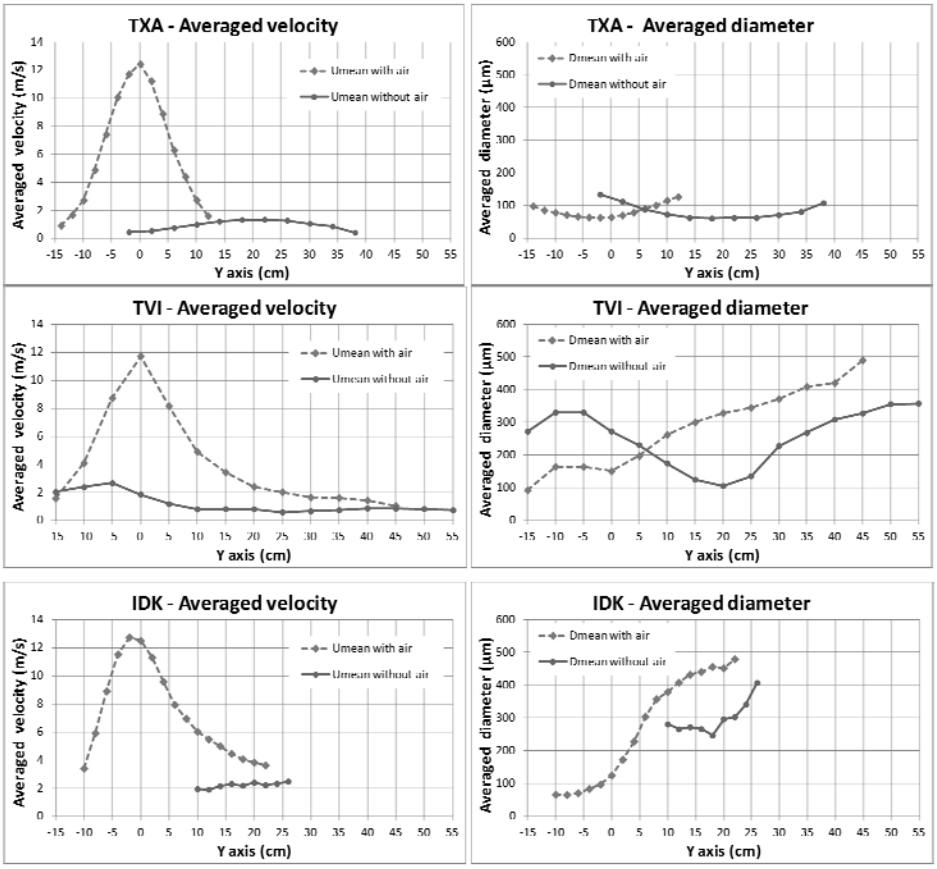

Figure 2: Averaged velocity (left) and averaged diameter (right) of the three nozzles TXA, TVI, and IDK, with air (blue dotted line) and without air flow (red solid line).

Concerning the TXA nozzle, the averaged diameter profile is only translated along the y axis due to the air flow. Concerning the TVI nozzle, without air the averaged diameter profile is a classical one, composed of smallest values near the spray centre and larger values at the edges. With air, there is a spatial redistribution of droplets along the y axis: largest droplets provided with highest kinetic energy go through the air flow whereas smallest ones can not and stay in the region y<0.

Concerning the IDK nozzle, without air, averaged diameters of 300 microns along the minor axis of the ellipse are obtained (y between 10 and 25 cm) whereas with air, the spray spreads (y between -10 cm and +20 cm). The same diameter gradient along y axis as for the TVI nozzle is found: smallest averaged diameter values for y<0 and larger averaged diameter values when increasing y).

These results are consistent with those previously obtained by our colleagues from IFV/Irstea using the EvaSprayViti test bench, which show that deposits are increased by air flow addition using TXA nozzle.

References

[1] Vallet, A. and Tinet C. Optimization of vineyard spraying based on physical criteria: a preliminary study on early growth stage. Ageng 2014, Zurich, 6-10 July.