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Evaluation of aerial drift during drone spraying of an artificial vineyard

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Drones have many advantages over the helicopters that were used in steeply sloping vineyards before the ban on aerial spraying. They are cheaper, safer, quieter, more precise and smaller, allowing them to fly lower and thus limit aerial drift. The drone also appears to be a promising alternative to ground spraying (the only option currently authorized) in terms of operator safety and exposure.

Given these advantages, the French authorities granted a waiver from 2019 to 2021, allowing experiments to assess the utility of drone spraying in plots with a slope greater than 30 %. As part of the PULVEDRONE project, UMT EcoTech has set up trials with the goals of (i) assessing the factors influencing the level of aerial drift during drone spraying and (ii) comparing drift levels from drones with those of the ground spraying devices currently used in steeply sloping vineyards.

A drift measurement test bed

Drift measurements were performed on the EoleDrift[1] test bed, which generates wind perpendicular to the rows of vines (initial cross-section 25 m^2, air flow rate 200 $m^3.s^{-1}$)[2]. During the trials, the devices spray a mixture containing a tracer (Brilliant sulfaflavine). A vertical drift collection device made up of 2 mm diameter wires is installed downwind. After the spraying trial, the collection wires are recovered and analyzed in the laboratory. For each collection height, the aerial drift index (I_D) is calculated as the ratio in ppm between the quantity of tracer collected and the total quantity sprayed.

Experimental results

Protocols tested

The trials were conducted with an AGRAS T16 drone (DJI, China) supplied by CymDrones (Haute-Marne, France). The T16 is a 6-rotor drone equipped with 8 nozzles. Its payload volume is 16 L with a gross laden weight of 40.5 kg. Three different nozzles were tested to generate variations in droplet size distribution, with a volume median diameter (VMD) of 109 µm for Teejet XR 110 01 (XR) nozzles, 190 µm for Albuz ADI 110 01 (ADI) nozzles and 512 µm for Lechler IDK 9001 (IDK) nozzles. Flight heights of 2.5 m and 3.5 m above ground level were tested (1 m and 2 m above the artificial vineyard respectively).
Two ground spraying devices used in steeply sloping vineyards were assessed to compare them with the drone: a STIHL SR200 backpack sprayer and an axial fan sprayer mounted on a NIKO HY38 caterpillar tractor. The data discussed in this article is available online[3].

Factors influencing aerial drift during drone spraying

In the absence of wind, whatever the nozzle used, the drift is reduced to a slight signal near the ground, and very weak to nil above 1 m in height. The drone's airflow does not, therefore, generate significant aerial drift.
In the presence of artificial wind (speed of approximately 17 $km.h^{-1}$ in the collection area), the drift measured by I_D index is 21.5 times greater on average than in the absence of wind. The I_D index is highly variable, with a ratio of 1 to 7.5 depending on the protocol tested.



FIGURE 1. AGRAS T16 (DJI, China) in test flight at the EoleDrift facility, UMT EcoTech, Montpellier (France).

There are two factors in particular that reduce drift (Figure 2):
➡Flight height: reducing the height from 3.5 m to 2.5 m results in a 76 % decrease in drift, regardless of the nozzle tested.
➡Larger droplets: compared with XR nozzles, the I_D index is reduced by 68 % with IDK nozzles, and 39 % with ADI nozzles. The I_D index for anti-drift nozzles is also relatively lower on the highest wires.

Flying lower and equipping the drone with an IDK anti-drift nozzle ultimately results in a 92 % reduction in the I_D index compared with flying at 3.5 m with XR nozzles.

Comparison with ground spraying devices

The drone generates a drift profile in inverse proportion to its height: the I_D index is halved for each meter gained in height. This atypical drift profile is explained by the descending airflow generated by the drone rotors, which tend to push the airflow towards the ground. Between 75 % and 96 % of the aerial drift from the drone is collected at between 0 m and 2 m in height. In comparison, most of the aerial drift (52 %) from the caterpillar tractor is captured above 2 m in height. The mean I_D index of the drone equipped with IDK anti-drift nozzles when flying at 3.5 m is slightly lower than that of the backpack sprayer, at 15.7 and 19.8 respectively.
The I_D index for the caterpillar tractor is the lowest measured, with an overall average of 6.2. Nevertheless, above a height of 2 m, the I_D of the caterpillar tractor is 50 % higher than that of the T16 drone with anti-drift nozzles flying at an altitude of 3.5 m (5.9 compared with 4.0). This fraction of the drift is likely to be carried a greater distance

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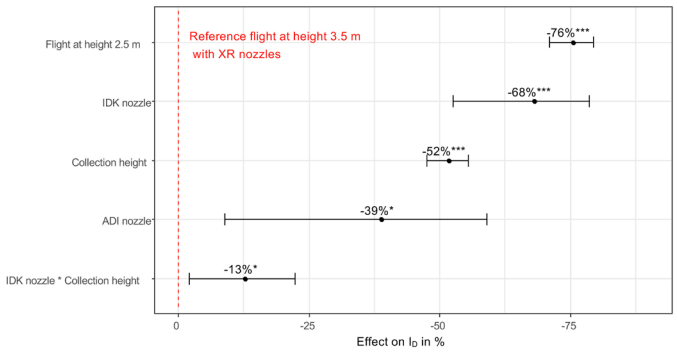


FIGURE 2. Effect of the various factors studied on the ID index compared with the reference (flight height of 3.5 m, Teejet XR 110 01 nozzle). ***: highly significant effect at a p-value of 0.001; *: significant effect at a p-value of 0.05. Non-significant factors are not shown.

than the drift closer to the ground.

Flying closer to the ground, at a height of 2.5 m, or approximately 1 m above the canopy, results in a significant reduction in I_D, with a more favorable profile than ground spraying if the drone is additionally equipped with anti-drift nozzles.

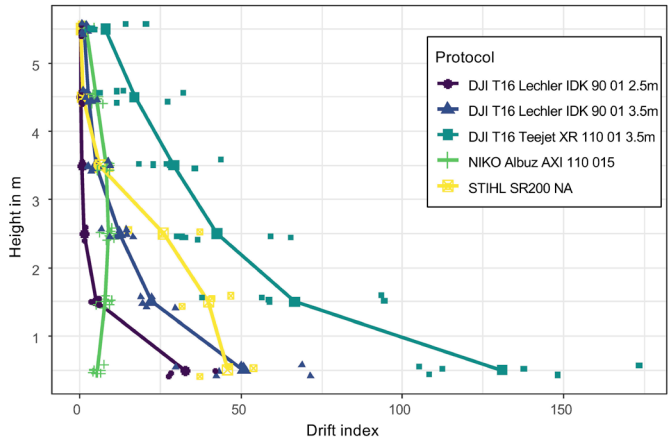


FIGURE 3. Mean drift profiles for the protocols tested, at a volume per hectare of 140 L/ha corresponding to a flight speed of 1.4 m.s-1.

Conclusions

These trials carried out under standardized conditions with EoleDrift show that with suitable settings, the aerial drift from drone spraying is equivalent to or less than that obtained with the devices currently used on steep slopes, including with wind speeds at the upper limit of acceptable speeds according to best agricultural practice. From a practical point of view, compliance with the following recommendations should make it possible to control the level of drift when applying plant protection products by drone:

➡Spray in low to zero wind conditions (from experience, Swiss operators avoid drone spraying at wind speeds above 10 km.h^{-1}).

➡Fly as low as possible and avoid exceeding 2 m above the canopy.

➡Use anti-drift nozzles. However, biological effectiveness when using anti-drift nozzles has not yet been assessed over the course of a spraying season.

➡Installing living or artificial hedges could also help to contain the drift generated by the drone, which is mostly collected at between 0 m and 2 m in height. ■

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