# Working Quality, Drift Potential and Homologation of Spraying Drones in Switzerland

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**Abstract:** Unmanned multicopters offer an interesting potential for the application of plant protection products in vineyards with steep slopes. Under such conditions, they can replace manual work and are an alternative to applications by helicopters. In Europe, no homologation process for unmanned aerial vehicles (UAV) exist so far. To fill this gap, a standard procedure has been elaborated in Switzerland and been in force since 2019. In addition to the measurements of common sprayer tests, the lateral wind speed caused by UAVs in 10 m and 20 m distance was chosen for the assessment of the risk of spray drift. The uniformity of the transversal spray distribution was measured by means of adapted patternators. UAVs reached satisfactory lateral distributions with variation coefficients of 6-15 %. During this first year, the testing methodology and the homologation process worked well and will be further applied in the coming years.

**Keywords:** Spraying drones, plant protection, unmanned aerial vehicle, homologation

## 1 Introduction

Since 2017, first trials with unmanned aerial vehicles (UAV) for the application of plant protection products have started in Switzerland. This is contrasting to Asia, where in China alone, over 10,000 UAVs are in use for spraying purposes [HB17]. To date, no standardized procedure exists to officially homologate and test their working quality. As aerial applications need a particular permission in Switzerland [BA16], a standard procedure to homologate the spraying UAVs needed to be developed. The motivation to use these small aircrafts in Switzerland is due to the negative perception of helicopter applications in steep vineyards, which are linked to noise and spray drift. It is estimated that over 50 % of the 15,700 ha of vineyards [Sc18] are so steep that they cannot be accessed by means of a tractor. Therefore, the application of plant protection products has to be performed with small orchard sprayers mounted on manually driven track vehicles, by hand or alternatively by helicopter. UAVs open new opportunities for such conditions. In contrast to the strong airstream of big and heavy helicopters, UAVs, which currently weigh between 20 and 40 kg, create a weak airstream and fly about 2 m above the crops.

With their multiple horizontally rotating rotors, multicopters cause a vertical airstream, which guides water drops towards the ground. In contrast to the airflow of conventional orchard sprayers, which is oriented in a horizontal or upward direction. This vertical, soil oriented airstream of drones reduced the drift of plant protection products [Du19]. These

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positive properties motivated different actors to establish a procedure to homologate drones for the application of plant protection products in Switzerland. The testing procedure developed in this study strongly relies on the standard procedures for sprayers (ISO 16122 & 16119). These prescriptions are complemented by the measurement of the lateral airflow speed, to achieve a reliable indication about the spray drift potential of the UAVs. The whole procedure has been published at www.bazl.admin.ch/drohnen. Like all other sprayers, UAVs have to pass a sprayer test every three years.

This paper presents some of the methods used that are part of the homologation of spraying UAVs in Switzerland.

## 2 Material and Methods

To quantify the spraying accuracy and to estimate the risk of a possible spray drift, two homologation methods have been developed. They have been applied within the frame of the Swiss homologation process, which started in 2019. The tested drones, 13 in total, belonged to enterprises that offer drone spraying services.

### 2.1 Tested UAVs: Huanaco and DJI Agras MG 1

All measurements were executed by means of two different multicopters (Table 1). The first one, a UAV of Homeland Surveillance & Electronics (Casselberry FL, USA), had been slightly modified by Agrofly (Monthey, CH). The second was the DJI Agras MG-1 (Shenzen, CN). For the measurement of the lateral spray distribution, 4 UAV1 and 9 UAV2 from different owners were tested within the frame of the Swiss homologation procedure.

| Parameter | UAV1 | UAV2 |
|---|---|---|
| Producer | Homeland Surveillance | DJI |
| Type | Huanaco AG-V6A | Agras DJI MG-1 |
| Number of rotors / engine | 6 / TTA 1030 | 8 / DJI6010 |
| Rotor diameter | 76 cm | 54 cm |
| Width (incl. propellers) | 236 cm | 204 cm |
| Full weight | 37.5 kg | 24.1 kg |
| Volume spray tank | 15.2 lt | 10 lt |
| Number of spraying nozzles | 4 | 4 |

Table 1: Technical description of the two used multicopters

### 2.2 Transverse volume distribution and wind speed

According to ISO 16122-2 [IS15], a patternator was used to determine the uniformity of the transverse volume distribution of the sprayed liquid. The patternator was modified to reach a width of 3 m and a length of 6 m. The width and depth of the single grooves were 10 cm. During the measurement, the drones hovered constantly in the middle of the patternator at a height of 2.5 m. The UAV sprayed in the same position until the first measuring cylinders, which captured the liquid of the grooves, contained roughly 100 ml. Subsequently, the volume in the measuring cylinder was measured and the coefficient of variance of the lateral distribution was determined according to the above-mentioned ISO-norm.

We performed measurements of the lateral wind speed in a 10 m and 20 m distance of the drones flight to determine the risk of occurring spray drift. The wind sensors (Thies Clima, Ultrasonnic Anemometer 3D 4.3830.20.340, Göttingen, DE) were positioned at two measuring heights. These sensors measured the wind speed with a frequency of 10 Hz in three directions (x, y, z). From each measuring point, the wind speed sum of the three directions was calculated to acquire the maximum non-directed wind speed. The UAV hovered at a height of 2.5 m, fully loaded on a length of 50 m, in which the sensor was placed in the middle. This measuring procedure was applied with one UAV1 (two replicates) and with one UAV2 (four replicates).

## 3 Results

### 3.1 Uniformity of the transversal volume distribution and wind speed

The 13 UAV1 and UAV2 tested on the patternator reached coefficients of variation (CV) between 6 % and 15 %. The average of UAV1 was 12.2 % and the one of UAV2 was 9.4 %. The differences between the two UAV platforms were not significant (Fig. 1). The influence of the flying height on the regularity of the distribution was significant. The lateral distribution was significantly improved with a flying height of 2.5 m (CV 12 %) compared to 1 m (CV 39 %). At the height of 1 m, nearly no liquid was measured in the middle of the drone, hoovering constantly at the same place (Fig. 1).

UAV1 reached maximum wind speeds of about 3.5 m/s in a distance of 10 m in a height of 0.75 m. Almost all other measurements of UAV1&2 were below 1.5 m/s (Fig. 2).

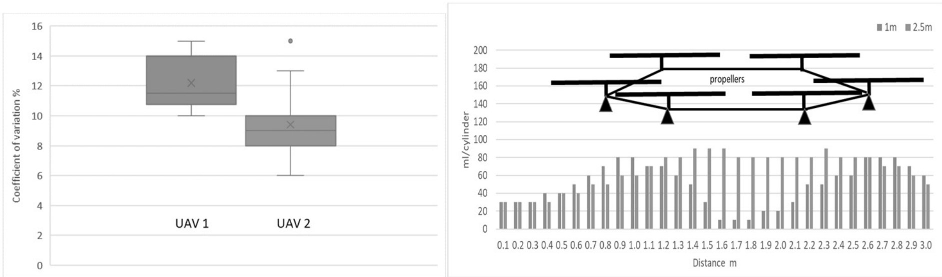


Fig. 1: Transversal liquid distribution: coefficient of variation of 4 UAV1 and 9 UAV2 (left); transversal distribution of 1 drone UAV2 at flying heights 1 m and 2.5 m (right)

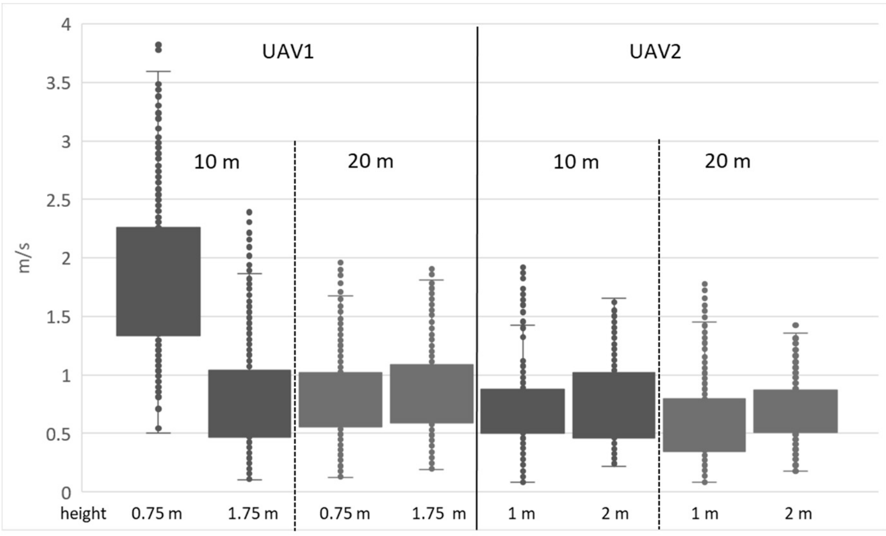


Fig. 2: Lateral wind-speeds during the flight of UAV1 measured in 10 and 20 m distance in two different measuring heights

# 4 Discussion

## 4.1 Uniformity of the transversal distribution

The measurement of 13 different drones showed that the modified patternator is a well adapted method to measure the regularity of the distribution of spraying drones. However, the precision of the drones in this study would not pass the requirements for field sprayers, for which ISO 16119-2 allows a maximum coefficient of variation of the transversal distribution of 10 %. This value was achieved for some measurements but most results lay within the range of 10-15 % CV. As UAVs are mainly used for the treatment of vines, for which no specific regulation exist, a maximum CV of 15 % has been defined to pass the homologation procedure in Switzerland.

The flying height plays an important role in terms of the regularity of the distribution. For the presented measurements, a height of 2.5 m was chosen. A height of only 1 m results in a much poorer distribution (Fig. 1). This is a consequence of the airstream caused by the propellers. Fengbo et al. [Fe18] and Yang et al. [Ya17]) showed that the airstream of the single propellers of a multicopter join to a regular airflow in about 2 m flying height. Above this height, the output of the 4 nozzles is regularly distributed over the working width. Below this height, the output is concentrated below the area of a single propeller under which the nozzles are placed. Between two propellers, the spray volume is much lower, as shown in Fig. 1. This means that flying heights lower than 2 m will cause a strip wise uneven transversal distribution.

The distribution width is very much limited to the width of the UAV. Both UAVs achieved a regular distribution width of about 2.0-2.3 m. A working width of about 250 cm can be achieved by overlapping the working width of two passages. Chen et al. [Ch17] confirm that the spray width is limited by the size of the cylindrical airstream caused by the propellers.

### 4.2 Wind speed measurements

UAV's with 6 and 8 propellers have shown very particular properties of their generated airstreams. Very low maximum wind speeds below 3 m/s occur in a distance of about 10 m from the UAV. In a distance of 20 m and a height of 2 m, the wind speeds are lower than 1 m/s. Compared to standard orchard sprayers, which generate big and strong airstreams of about 8 m/s [Tr12] and which are directed laterally and not towards the soil, the risk of pesticide drift is lower. These results have been confirmed by field trials measuring the spray drift according to ISO 22866 [Du19]. According to the simulations of Fengbo [Fe18] and Yang et al. [Ya17], the drops are pushed downwards by the airflow of the single propellers. Outside the area of the propellers the wind speed is very low, which means that, there, no drops are transported by the wind. The low wind speeds, the simulations and the field measurements confirm the low risk of spray drift of multicopters. Based on these results, wind speed measurements are considered as a well adapted parameter to estimate the risk of spray drift. In Switzerland, they serve to homologate spraying drones. The airstream caused has to be lower than the following limits: distance of 10 m: in heights of 1 m and 2 m, max. allowed values are 5 m/s resp. 3 m/s in 20 m distance these values are 3 m/s and 2 m/s resp.. If these values are fulfilled, no drift measurement according to ISO 22866 [IS05] is demanded for the homologation of new types of UAV.

### 4.3 Homologation in Switzerland

Based on the presented results, a homologation procedure and a sprayer test for spraying UAVs was developed in collaboration with the federal offices for environment, agriculture, health, economic affairs and aviation. The details of the homologation are presented on the webpage of the federal office of aviation https://www.bazl.admin.ch/drohnen. Apart from the presented parameters, the tests are complemented by several other measurements according to current sprayer tests.

This procedure has proven to be well adapted to guarantee a precise, secure and environmentally friendly application of plant protection products.

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