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Evaluation of the performance of drone treatments to control downy and powdery mildew in grapevines

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1 Introduction

In the context of precision agriculture, the use of technological tools is becoming more and more widespread to accomplish various tasks, from the simplest to the most complex. The vineyard is also experiencing the development with the appearance of various autonomous robots and drones that can perform diverse tasks. Crop protection has not escaped this evolution with the appearance of drones specialized in treatments (Rao Mogili & Deepak 2018). The use of drone for plant protection product (PPP) application, also referred as Unmanned Aerial Spray Systems (UASS), is new in Europe but quite common in Asia since a decade (OECD, 2021). In Switzerland due to the topography, significant parts of the vineyards are cultivated in steep slopes or terraces. No mechanization is possible in these very steep areas and the cultivation of the vines requires a lot of manual work. PPP spraying is done either with knapsack sprayers or guns. Contrary to Europe where they are forbidden, in Switzerland aerial applications with helicopters are still allowed and about 1000 ha were concerned in 2021. However increasing limitations and constraints has led to a decrease of about 40% in treated areas over the last five years.
Growers are looking for new alternatives that are less painful. That is why drone has attracted attention since 2016. After a pragmatic and efficient analysis of the technique, Switzerland was the first country in Europe to authorize treatments by drone and to set up a procedure regulating their use in 2019 (Anken & Waldburger 2020). From 2018, a handful of companies have begun spraying small areas under the regulations for helicopters. From 2019, the surfaces more or less doubled each year to reach nearly 400 ha in 2021. This development will continue because the demand is strong. Different business models emerged from companies selling spraying drone to full-service companies that take entirely care of the plant protection from the product selection based on the production method, the timing and the application throughout the season. The latter is possible as some nonprofessional and professional growers are used to outsource the plant protection to third parties like helicopter spraying companies.

2 Control performance of drone spraying

A central question for the growers is what is the performance of drone PPP applications. A project funded by the Federal Office for Agriculture (FOAG) and led by an extension service, Proconseil (Lausanne, VD) in collaboration with Agroscope and three drone companies investigated during three years (2018-2020) the control efficacy and application quality of drones. To evaluate the performance of drone application, comparisons of the protection efficacy of drone-treated areas with air-blast sprayers or knapsack sprayers-treated reference areas were conducted on four plots per year. Applications were made on the same day with the same products, only the application technique varied. The plots of approximately 1'000 m^2 were divided into three blocks corresponding to the drone treatment, the ground treatment, an small untreated control. In five locations a fourth "drone-ground" hybrid modality that consisted of drone spraying all over the season with one or two additional ground sprays directed in the bunch zone. All sub-plots were sprayed the same day with the same products and managed same way. The only difference was the spayer used. Diverse spraying programs including IPM, Organic and Organic + Phosphonate, were tested in the different plots. The presence of Downy and Powdery Mildew was assessed three times during the season.

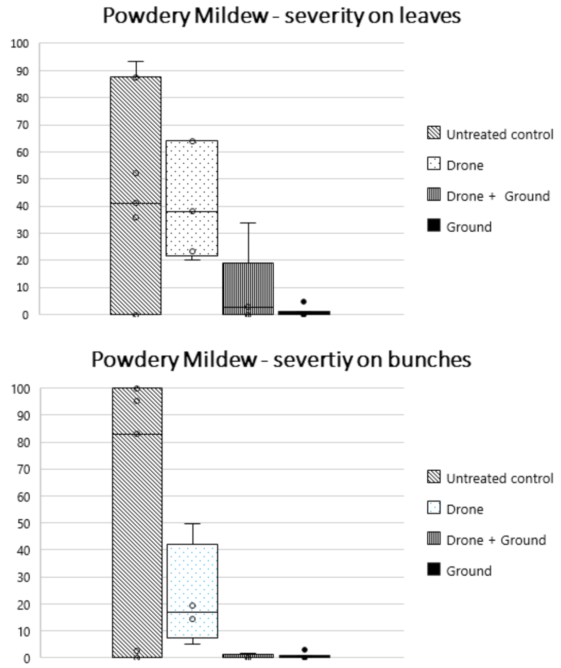

Figure 1: Summary of Powdery Mildew occurrence on leaves and bunches in severity in selected trials from 2018 to 2020.

The disease pressures were different according to location and year. Downy Mildew was limited in most of the plots but Powdery Mildew showed very high pressure in some plots. The results for Powdery Mildew are summarized in Figure 1. The effectiveness of the different application techniques varied greatly depending on disease pressure. When disease pressure was low, there was almost no difference between the different application techniques. The observation is quite

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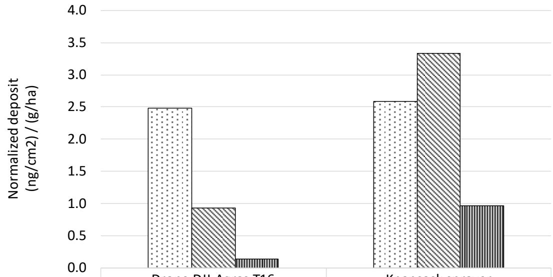
different when the pressure becomes more important. The effectiveness of the drone treatments decreases by higher diseases pressure and is halfway between the control and the ground applications. In cases of extremely high pressure, the effectiveness of the drone protection drops off completely and there is little difference between the untreated control and the drone protection. In these trials, this observation applies particularly to Powdery Mildew, which is a disease that is easily expressed when the quality of application is not sufficient, but is also valid for Downy Mildew in case of high pressure as in 2021. The variants treated by drone systematically present more damage than the reference ground application and this observation is valid for both diseases. In the case of the test plots with a high pressure of Powdery Mildew, the harvest of the drone sprayed variant was totally lost. On the other hand, drone treatments with one or two complementary ground spray allow getting similar control effectiveness as in ground treatments. This is consistent with the experience of aerial treatments with helicopter where at least one additional ground treatment in the bunch zone is required..

3 Application quality

To quantify the deposition on leaves and bunches, a fluorescent marker was added to the treatment mixture. After treatment, 10 samples of 15 leaves and 15 bunches were collected. The fluorescent marker was recovered from the surface of the leaves and bunches respectively using isopropanol. The fluorescence was then quantified using a spectrometer (Siegfried et al., 1990 and 2007). The deposition is expressed in ng/cm^2 and then the values are normalized to the amount of marker applied (g/ha) in order to compare different applications. In addition, it is possible to visualize the distribution of the marker under a UV lamp and to take pictures of it.



	Drone DJI-Agras T16	Knapsack sprayer
Leaves top	2.48	2.59
Leaves down	0.93	3.34
Bunches	0.14	0.97

Figure 2: Quantification of product deposition in the different compartments of the foliar hedge using a fluorescent marker in Paudex (VD) in 2020. Comparison of the deposit obtained during the last treatment in August with the DJI AGRAS T16 drone and a backpack sprayer.

In aerial applications, the spray is applied from above on a vertical foliar hedge. This makes it difficult to reach the bunch area. This problem is already well known for helicopter applications. The comparison of the amount of product deposited with the drone and with the sprayer during a treatment in a trial in Paudex (VD) shows important differences (fig. 2). Compared to the sprayer, the drone deposited an equivalent amount of product on the upper leaves but 3.6 times less on the leaves in the cluster area and 7.1 times less on the clusters. This strong decrease of the quantity of product when going down towards the bunches explains well the limits in control efficacy observed in Paudex in 2020 as well as in other plots of the network. According to these values, the need for at least one additional ground treatment of the bunches zone becomes obvious.

Figure 3 visually confirms the difference in deposition between the upper leaves and those in the cluster area. Moreover, only the adaxial side (upper side) of the leaves is well covered and the abaxiale side (underside) is almost not covered with product. However, the Downy Mildew penetrates the leaf via the stomata that are located on the abaxial side of the leaf. The very low coverage of the abaxial of the leaves reduce the performances of drone treatments against Downy Mildew, especially if contact products are used exclusively like in organic production.

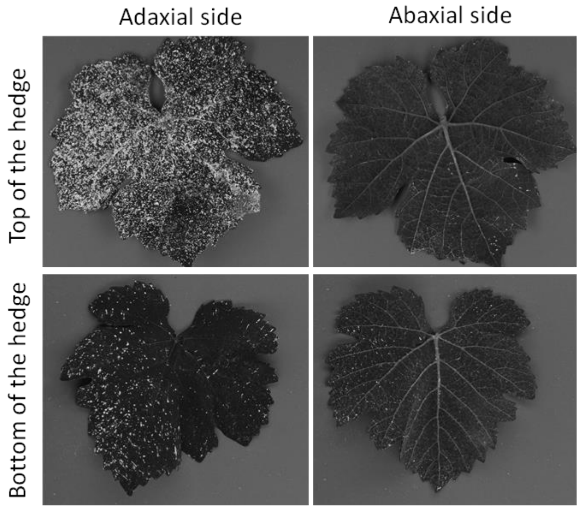


Figure 3: Qualitative evaluation of the deposit by visualization under UV light of the fluorescent marker in the different areas of the leaf hedge and both leaf side (adaxial and abaxiale).

4 Conclusions

- Drones have an interesting potential, especially for steep slope plots and terraces that are non-mechanizable. It allows replacing painful manual sprays.
- Bunches receive limited quantities of product when applied by drone compared to conventional sprayers. Furthermore, the coverage of the abaxial side of the leaves is very low which affects the control performance because it is where the stomata are located.
- With high diseases pressure, the effectiveness of the treatments by drone is halfway between the control and the ground applications. In cases of extremely high disease pressure, the effectiveness of drone protection drops off completely with significant harvest losses.
- The combination of the drone with at least one complementary spray from the ground allows reaching reasonable levels of control in case of average to strong disease pressures.

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