# Different water consumption and fungicide drift in control of grapevine downy mildew

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## 1 Introduction

Grapevine (*Vitis vinifera*) is one of the most important agricultural plants in Montenegro. Its cultivation increases from year to year. According to the data of the Montenegro Statistical Office (2021), grapevines were grown on an area of 2888 ha. Diseases caused by phytopathogenic fungi are among the factors that could limit grapevine production. The most important grapevine diseases in Montenegro are: Phomopsis cane and leaf spot (*Phomopsis viticola*), grapevine downy mildew (*Plasmopara viticola*), grapevine powdery mildew (*Erysiphe necator*), gray mold (*Botrytis cinerea*) and esca (Latinović and Latinović, 2011).
The greatest damage and the highest cost of control are due to the presence of grapevine downy mildew.

Grapevine downy mildew is a disease of warm and wet weather conditions and is widespread almost everywhere grapevines are grown (Gessler et al., 2011). The European vine (*Vitis vinifera*) is extremely susceptible to this disease. In order to ensure a high yield and quality of grapes, proper chemical protection is necessary. Effective chemical protection, in addition to the selection of an adequate plant protection product, also depends on the time of treatment, as well as qualitative fungicide application (Sedlar et al., 2014). In order to achieve maximum efficiency in protection, the method of pesticide application should be controlled and optimized (van de Zande et al., 2008). According to EU Directive 2009/128/EC which establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promotes the use of integrated pest management, the influence of different treatment volumes on pesticide drift was examined in the paper.

The aim of the research was to examine the individual as well as the combined influence of different water volumes applied, and the position of the axial fan blades on the control of the disease causal agent *Plasmopara viticola*. In addition, the influence of these factors on fungicide solution reaching the ground (drift) at different stage pressures and positions of atomizer axial fan blades was investigated.

## 2 Materials and Methods

The experimental was conducted during 2020 at the trial field of the Biotechnical Faculty. The selected vineyard plot comprised of 1.05 ha with the autochthonous variety Vranac. There were 50 rows of vines in total with the distance between rows of vines of 2.4 m and the row length of 87.3 m. The experimental plot was divided into three smaller ones (consisted of 15 rows each) and a control plot (consisted of 5 rows). For the application of fungicides, tractor-mounted atomizer manufactured by Agromehanika Kranj, with a capacity of 330 liters and an axial fan (Ø 825mm) with an air capacity of 15000-45000 $m^3/h$ was used.
For each 15 rows, a different volumes of water consumption were used, depending on different pressure. Namely, three different pressures were used for the same nozzle, and consequently three different water consumption volumes were applied: Volume 1 at 8 bar pressure ranged from 109 to 436.6 l/ha, Volume 2 at 14 bar pressure ranged from 144 to 576.6 l/ha and Volume 3 at 20 bar pressure ranged from 172.5 to 690 l/ha.

For each volume, the atomizer fan blade is adjusted to three different positions. Within a plot of 15 rows, fan position 1 was used for the first five rows, fan position 3 was used for the other five rows and fan position 5 was used for the rest. Volume was calculated according to the formula shown in Fig. 1. The position of the blades on the atomizer fan defines the air volume, where position number 1 distributes the smallest air volume while position number 5 distributes the largest air volume.


Figure 1: Formula for calculating water consumption volumes

Hollow cone nozzle Lechler TR-80-02 was used during the research. The number of nozzles was determined in relation to the growth stage of vine and it ranged from 2 to 8 nozzles on the atomizer.
In order to adequately protect the vine, a total of seven treatments were performed in 2020. The first two treatments were performed primarily to control Phomopsis cane and leaf spot, while for the rest of treatments plant protection products were applied to control grapevine downy mildew and grapevine powdery mildew. For first two treatments Cadilac® (mancozeb) was used; for the third, fourth and fifth treatments Profiler® (a.i. fosetyl-Al + fluopicolide) was applied, for the sixth treatment Mildicut® (cyazofamid) was used while for the seventh treatment Ridomil Gold Combi® (metalaxyl-m, folpet) was applied.
To control grapevine downy mildew, seven treatments were performed on 13 April (BBCH 13), 26 April (BBCH 19), 11 May (BBCH 53), 19 May (BBCH 63), 28 May (BBCH 75), 12 June (BBCH 81) and 25 June (BBCH 83).

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Assessment of downy mildew symptoms on grapevine leaves was performed twice (on May 26 and June 19) according to EPPO standards. Total of 200 leaves were inspected in relation to water consumption volume and position of fan blades (EPPO, 1997). The yield assessment was performed on September 10 and referred to the total yield from 15 vines per treatment.

To determine the amount of drift, a tracer Brilliant blue 80% purety in a dose of 500 g per 100 l of water is used according to methodology described by Višacki et al. (2018). The application of tracer and water solution during the spraying season was performed two times (on June 12 and on June 25). Petri dishes with a diameter of 9 cm were used to collect the tracer that reached the surface of the land. They are distributed on land surface in three locations: at the beginning, in the middle and at the end of row, arranged laterally in relation to the movement of atomizer (7 dishes on the left and 7 dishes on the right side of the atomizer). Distance between Petri dishes was 0.75 m so drift monitoring covered up to 5.25 m from the treatment site.
After spraying performed, Petri dishes were washed in the laboratory with 50 ml of deionized water and the collected samples were read on a Jenway 6105 UV/Vis spectrophotometer at a wavelength of 625 nm. The obtained readings were statistically processed by the IBM SPSS Statistics program 24.

## 3 Results

Na kontrolnoj parceli u prvoj ocjeni (Tab. 1) evidentirana je infekcija vinove loze pseudoglje (*Plasmopara viticola*) u procentu od 16.5% obuhvaćenosti listovima dok je u drugoj ocjeni (Tab. 2) obuhvaćenost listova bio 42.5% (EPPO, 1997).
The evaluation of the treatment efficiency showed that there were no differences between the plots treated with Volume 1, Volume 2 and Volume 3. Likewise, the position of fan blades did not affect the efficiency of protection. In the first assessment of control plot (Tab. 1) disease severity was recorded in the percentage of 16.5% leaf coverage while in the second assessment (Tab. 2) leaf coverage was 42.5%.

Table 1. First assessment

| **Volume of water consumption** | **Fan blade position** | **Disease severity (%)** | **Efficacy (%)** |
|---|---|---|---|
| 1 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| 2 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| 3 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| **Control** | 16.5% | | |

Table 2. Second assessment

| **Volume of water consumption** | **Fan blade position** | **Disease severity (%)** | **Efficacy (%)** |
|---|---|---|---|
| 1 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| 2 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| 3 | 1 | 0.0 | 100 |
| | 3 | 0.0 | 100 |
| | 5 | 0.0 | 100 |
| **Control** | 42.4% | | |

The total yield ranged between 68.2 to 68.8 kg per 15 vines, while the yield in control was 10.1 kg per 15 vines as shown in Table 3.

Table 3. Grapevine yield per 15 vines

| **Volume of water consumption** | **Fan blade position** | **Yield** (kg) |
|---|---|---|
| 1 | 1 | 68.3 |
| | 3 | 68.2 |
| | 5 | 68.4 |
| 2 | 1 | 68.6 |
| | 3 | 68.8 |
| | 5 | 68.7 |
| 3 | 1 | 68.6 |
| | 3 | 68.6 |
| | 5 | 68.7 |
| **Control** | 10.1 | |

Concerning the drift, statistical data processing using Two way ANOVA, Tests of Between-Subjects Effects for significance P <0.05 revealed that the volume of water consumption and distance from treatment site have statistically significant effect on the concentration of deposited tracer (Tab. 4).

Table 4. Results obtained by Two way ANOVA

| **Dependent Variable:** | | |
|---|---|---|
| Source | F | Sig. |
| Corrected Model | 4.207 | 0.000 |
| Intercept | 652.70 | 0.000 |
| Volume of water consumption | 3.273 | ***0.039** |
| Fan blade position | 1.230 | 0.294 |
| Petri dishes on the left or right side | 0.733 | 0.393 |
| Distance from the treatment site | 69.118 | ***0.000** |

| | | |
|---|---|---|
| Volume of water consumption * Fan blade position | 0.769 | 0.546 |
| Volume of water consumption * Petri dishes on the left or right side | 0.145 | 0.865 |
| Volume of water consumption * Distance from the treatment site | 0.489 | 0.920 |
| Fan blade position * Petri dishes on the left or right side | 0.344 | 0.710 |
| Fan blade position * Distance from the treatment site | 1.069 | 0.387 |
| Petri dishes on the left or right side * Distance from the treatment site | 0.369 | 0.898 |
| Volume of water consumption * Fan blade position * Petri dishes on the left or right side | 2.175 | 0.072 |
| Volume of water consumption * Fan blade position * Distance from the treatment site | 0.513 | 0.973 |
| Volume of water consumption * Petri dishes on the left or right side * Distance from the treatment site | 0.505 | 0.910 |
| Fan blade position * Petri dishes on the left or right side * Distance from the treatment site | 1.078 | 0.379 |
| Volume of water consumption *Fan blade position * Petri dishes on the left or right side * Distance from the treatment site | 1.520 | 0.061 |

(P <0,05)

Results of Duncan test for significance level of P<0.05, for variable Volume of water consumption are presented in Table 5.

Table 5. Duncan test for variable Volume of water consumption

| Volume of water consumption | Mean concentration value of the collected tracer (ppm) |
|---|---|
| 1 | 7.9440 [b] |
| 2 | 9.3872 [ab] |
| 3 | 10.1582 [a] |

Different letters show differences in significance based on level P <0,05

Distribution of tracers on non-target surface is presented in Figure 2, while results obtained by Duncan test for variable Distance from the treatment site are shown in Table 6.

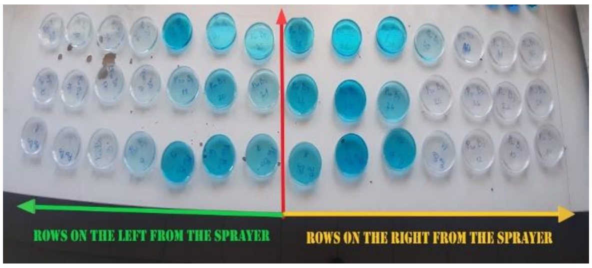


Figure 2. Petri dishes with collected tracer; red arrow indicates the direction of tractor movement

Table 6. Duncan test for variable Distance from the treatment site

| Distance from the treatment site | Mean concentration value of the collected tracer (ppm) |
|---|---|
| 7 | 1.922[e] |
| 6 | 2.546[de] |
| 5 | 3.546[de] |
| 4 | 5.098[d] |
| 3 | 12.199[c] |
| 2 | 17.211[b] |
| 1 | 21.619[a] |

Different letters show differences in significance based on level P <0,05

## 4 Conclusions

The research showed that during 2020 it was possible to protect the grapevine from downy mildew disease using lower volume of water consumption.
The study confirmed significant differences in the concentration of the tracer that reached the soil surface when using the lowest and highest water consumption for treatment. Namely, with less water consumption, the amount of tracer collected is smaller.
The largest amount of tracers was collected at a distance up to 2.25 m from the treatment site.
Based on obtained results, it can be concluded that using lower volume of water consumption in fungicide application can successfully protect the grapevine from downy mildew, while reducing the amount of fungicide solution that reaches the non-target surface and consenqently decrease a risk to the environment.

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