Laser-induced fluorescence spectroscopy in viticulture: An experimental study with *Plasmopara viticola* on potted vines under greenhouse conditions

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Abstract: Pathogenic fungi severely threaten the annual yield in viticulture. In our study we investigated leaves of potted vines and traced their development using our new remote detection system vinoLAS®, which is based on laser-induced fluorescence spectroscopy.

1. Introduction

Fungal diseases threaten the annual yield of grape harvests. In Europe, most cultivars of the widely planted grapevine species Vitis vinifera are susceptible to *Plasmopara viticola*, the causal agent of downy mildew. Downy mildew is one of the most destructive diseases affecting viticulture. So far, viticulture is missing a comprehensive and fast disease/pathogen assessment and fast monitoring tool to get an overview on the epidemiological status of each grape disease at a single site. Unlike manually based approaches, optical spectroscopy is a rapid, cost effective and non-destructive method, which does not require any sample preparation [1]. Nowadays, thermal [2] and hyperspectral [3] imaging are quite common techniques, but both are passive optical methods, whose signatures are influenced by environmental conditions. In contrast to that, active technologies, like laser-induced fluorescence spectroscopy (LIF), offer two major advantages. First, the active illumination with a pulsed laser enables gated data acquisition, which makes an efficient background suppression possible. Hence, the system can be used regardless of weather conditions (day- and night-time operation). Second, the laser enhances the sensitivity and selectivity, making such a system a promising diagnostic and monitoring technique in vineyards.

2. Measurements and Results

The vinoLAS research model is based on laser-induced fluorescence (LIF) spectroscopy. The system is unique as it is capable of multi-wavelength excitation (236nm, 355nm, 473nm, 532nm), which is especially optimized for non-invasive optical remote detection in viticulture. The simplified setup is depicted in Figure 1.

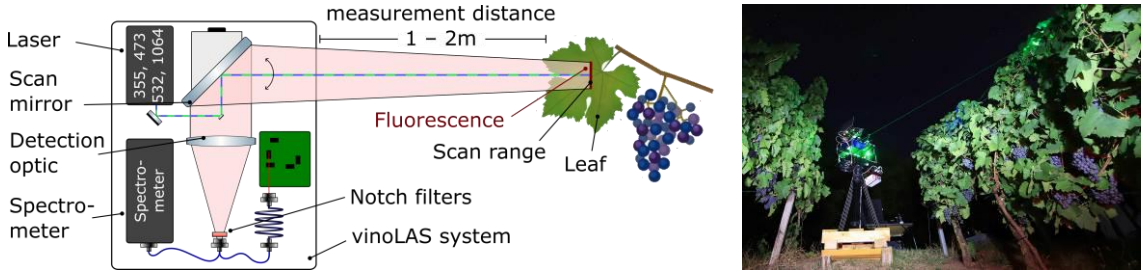

Fig. 1. Left: Schematic illustration of the experimental measurement configuration of the vinoLAS research model. The laser beams are guided through a scan mirror to the sample surface, where the LIF is excited. The fluorescence light is collected with a detection optic and coupled via optical fibers to a spectrometer and a four-channel data acquisition device. Right: Picture of the vinoLAS research model during a test measurement campaign in a vineyard.

In this study, we used the vinoLAS system for investigating LIF development on 20 potted vines (*Vitis vinifera L.* cv. Riesling) grown in a greenhouse [4]. These were divided into two groups which impose different treatments: (a) an inoculated group (ten potted vines; positive control) treated with a sporangia suspension of *P. viticola* at a

concentration of 1×10^5 ml^{-1}; (b) a non-inoculated group (ten potted vines; negative control) treated with demineralized water.

To determine the temporal development of the downy mildew infection, we acquired daily LIF spectra of all potted vines and observed the changes of the LIF signal over the course of 17 days in a measurement campaign. Exemplary, in Figure 2a the temporal development of LIF for an arbitrary potted vine of the inoculated group is shown for the excitation wavelengths of 355nm. The development of the subsequently calculated BFRR_UV index over the time course of the experiment is shown in Figure 2b.

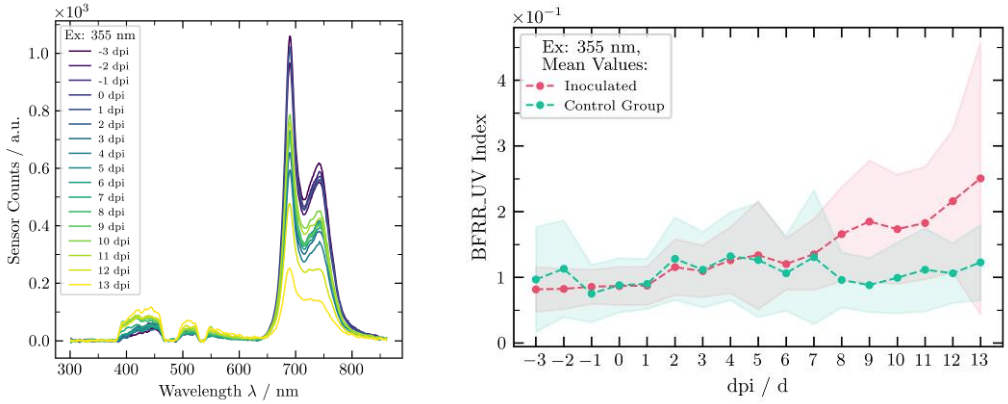

Fig. 2. Left: Laser-induced fluorescence spectra of an inoculated potted vine (cv. Riesling) (with downy mildew) for 355nm excitation wavelength. The different colors indicate the temporal development over the measurement campaign of 17 dpi. Right: Temporal development of the BFRR_UV-index for 355nm. The data for the group inoculated with downy mildew is marked in red, whereas the non-inoculated (healthy) group is marked in green (dashed line: mean, shaded area: standard deviation with reference to the mean value).

The results of the long-term measurements show that a temporal change in the LIF signal can be measured easily with the vinoLAS system. With the current analysis method based on the BFRR_UV index and ChlF ratio, a differentiation between the inoculated and healthy group is possible after 5 to 7 days after the inoculation. For comparison, the first visual symptoms of downy mildew can usually also be seen on leaves about 7 days after inoculation (greenhouse experiment) or infection (under natural circumstances in the vineyard), which additionally strongly depends on individual temperature conditions. Consequently, the vinoLAS system can be used as a monitoring tool for downy mildew, since there is a lack of quick and easy disease monitoring systems in viticulture at present. It could be very helpful in practice in order to obtain information on the start of the epidemic on the one hand and the effectiveness of fungicide applications within the course of the growing period on the other hand.

3. References

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