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

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vinoLAS® is an innovative research model, especially tailored for fast non-invasive remote detection of pathogens in viticulture.

Technology: Laser-induced fluorescence
Passive q-switched nanosecond lasers:
- excitation module 1: 236 nm, 473 nm
- excitation module 2: 355 nm, 532 nm
- reference wavelength: 1064 nm
- rep. rate: 5 kHz, pulse energy: 0.34 µJ
- Detection distance: 1 m – 2 m (typ. 1.6 m)

A comprehensive, fast disease/pathogen assessment and fast monitoring tool is missing in viticulture.

Experimental setup – vinoLAS®

Motivation
- Pathogenic fungi (Plasmopara viticola, Erysiphe necator) severely threaten the annual yield of grapes in quantity and quality.
- Goal of current grapevine protection strategies: Reduction of fungicides by 50% until 2030 [1–3].

Long-term measurements over 17 days
Day of inoculation with P. viticola: 0 dpi

Results – Temporal development of LIF

- Increase in blue-green fluorescence, measurable change of chlorophyll ratio

Results – In-field operation

- Test of vinoLAS® operational readiness in a trial vineyard

Results – Discussion

- Differentiation between healthy and an inoculated leaf tissue is possible (RQ 1).
- Pathogen symptoms are measurable by fluorescence detection after 7 dpi (RQ 2a).
- Hence, system can be used as a monitoring tool, but currently not for early pathogen detection (RQ 2b).
- LIF signal strength significantly varies between upper and lower leaf surface (factor 2.7) due to growth of sporangiophores on the lower side (RQ 3a).
- Detection capabilities have been elaborated in a field test. Influence of different grape varieties have to be considered in future studies (RQ 3b).
- By machine learning algorithms more information can be teased out of the vinoLAS system in future.

Sample preparation
- 30 potted vines (Vitis vinifera L. cv. Riesling) grown in a greenhouse in standard potting medium:
  - inoculated group [1] (10 potted vines): treated with a sporangia suspension of P. viticola (concentration: 1 \times 10^8 m⁻¹),
  - non-inoculated group [2] (10 potted vines): treated with demineralized water,
  - validation group (10 potted vines): unknown state of inoculation of the individual plants for experimental operator.

Results – Temporal development of BFRR_UV index and ChlF-ratio

Evaluation of integrated fluorescence bands by BFRR_UV index and ChlF-ratio:

Temporal change of BFRR_UV index and ChlF in case of infection after 7 dpi.

Outlook – Long-term objective

- Automated disease monitoring in a vineyard using the vinoLAS® technology
- Long-term investigations in trial vineyards at different disease pressure levels
- Optimization of the vinoLAS setup (gated detection, multi-wavelength excitation)

References