

Quality Management for vineyards through intra-vineyard and inter-plant monitoring of physiological plant indicators

Becker M.S.*¹ & A. Forneck

University of Natural Resources and Applied Life Sciences, Vienna, Austria

¹Corresponding author: (e-mail: manuel.becker@boku.ac.at, telephone: 0043-1-47654-3441, FAX number: 0043-1-47654-3359)



University of Natural Resources and Applied Life Sciences, Vienna
Department of Applied Plant Sciences and Plant Biotechnology

Abstract

On site variability in vineyards is a well-known fact caused by natural geological processes, soil properties and environmental factors. Recognition of these fine-scale variations is essential for grapevine management, especially for defining stressed vs. non-stressed areas, since stress seems to play a key role in producing high quality fruits and wines. The aim of this study is to define (1) intra vineyard variation; (2) to assess and evaluate a set of plant indicators reflecting the vine's physiological status and (3) to define parameters that correlate the plants status with fruit quality. Intra vineyard - and inter plant variation was monitored analysing the physiological condition of vines by water potential, gas exchange, chlorophyll fluorescence and nutritional status. The vineyards (Pinot noir/5BB) in the age of seven years, located at Vienna and Soos (Lower Austria) were randomly sampled (four times/year) and individual vines (133/ha) were randomly measured. Additionally a greenhouse trial with one-year old grapevines was conducted to differentiate inter plant variation employing to two different Pinot noir clones (four replications/plant; 15 replications/clone) under controlled environmental conditions. Fruits were randomly sampled at maturity and analysed by FTIR-spectroscopy. Data analysis has been carried out by interpolation of sampled data to predict parameter values of non-sampled grapevines in the vineyard. Interplant variation was measured to evaluate plant physiological parameters: only Parameters with insignificant variance between plant materials of same age and physiological status was used for mapping intra-vineyard variation. Execution of data analysis basing on correlations with stress impact factors (e.g. reduced photosynthesis efficiency) resulted in the definition of "stress" zones which facilitate efficient vineyard management for the growers.

Introduction

Variability in vineyards is well known. So-called subfield regions typically represent areas with different natural geological processes, soil properties and environmental factors. These variation usually associates with different stress levels. Bramley and Hamilton (2004) demonstrated that the patterns of within-vineyard spatial variation in yield were temporally stable. On this basis, tools or methods to accurately observe and measure the variation in vineyards are sought. Physiological status as well as nutrition levels are starting points to determine these differences.

Material and Methods

Plant material and sampling

The study was conducted in 2007 in two seven year old commercial vineyards in Austria at Vienna (16°19'21" O, 48°15'26" N) and Soos (16°11'56" O, 47°58'49" N) with sizes of 0,9 ha and 0,42 ha. Both were planted with Pinot Noir clone ENTAV 115 grafted onto 5BB respectively SO4 rootstock. Measurements were taken at great-sized berries (BBCH 73), touching berries (BBCH 79), veraison (BBCH 85) and before harvesting (BBCH 89). The sampling of fruits was based on a regular grid, 10 % were randomly selected. The dimensions of the grid were determined by the vine and row spacing, the nodes of the sampling grid were defined by the locations of the trunks of target vines. Samples were collected at an intensity of 133 samples/ha (Fig. 1).

Water status of plants

Plant water status was measured with a pressure chamber (PWSC Model 3000, Soilmoisture Equipment Corp., Santa Barbara, USA). $\Psi_{predawn}$ was measured at the end of the night (before sunrise) on uncovered leaves. Ψ_{leaf} was measured on mature leaves which remained exposed to direct sunlight at midday. Ψ_{stem} was measured on non-transpiring leaves that had been bagged with both plastic bag and aluminium foil at least 1 h before measurement. $\Psi_{predawn}$, Ψ_{leaf} , Ψ_{stem} were measured on the same vines.

Gas exchange and fluorescence measurements

Simultaneous measurements of gas-exchange and chlorophyll fluorescence were made by using an infrared gas analyzer (Ciras-2 with Cuvette PLC6, combined with CF-Modul, PPSsystems, Hitchin, Hertfordshire, UK). Net CO₂ assimilation rate was determined at a CO₂ concentration of 381 $\mu\text{mol mol}^{-1}$, 50 % relative humidity and artificial irradiance (1000 $\mu\text{mol m}^{-2}\text{s}^{-1}$). Fluorescence parameters were set following recommended values published in the CF-Modul manual (PPSsystems, Hitchin, Hertfordshire, UK) for dark- and far-red-light-adapted leaves. Saturation pulses of approximately 5100 $\mu\text{mol photons m}^{-2}\text{s}^{-1}$ with a 0.7 s duration were applied in order to saturate the PS II reaction centers for estimating Fm and Fm'. Parameter of gas exchange measurements: Pn, Trans, gs, Tleaf, rH, CO₂-Sub. Parameter of Chlorophyll-Fluorescence measurements: far-red adapted: Fo', Fs, Fm', PS2, qP, ETR; dark-adapted: Fo, Fo', Fs, Fm, Fm', Fv, Fv', Fv/Fm, Fv/Fm', PS2, qP, qNP, NPQ, ETR. Gas exchange and chlorophyll fluorescence parameters were taken three times, water potentials two times per vine.

Leaf nutrient analysis

Leaf nutrient contents were analysed at veraison by atomic spectrophotometry (Varian SpectraAA-300/400, Palo Alto, Calif., USA). Studied nutrients were Fe, Mn, Cu, Zn, K, Ca, Mg, P, N, and C. Each result for each sample is the average of two readings.

Statistical Analysis

Statistical analysis has been carried out with Vesper 1.6 rev. 3 (ACPA, The University of Sydney, NSW, Australia) and Surfer 8 (Golden Software, Inc., Golden, CO, USA)

Results

Results showed data of the vineyard in Vienna at different BBCH stages. Assimilation rate at veraison (Fig. 2) show values from 0.6 to 6.51 $\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$. Leaf nitrogen content at veraison (Fig. 3) of green fields indicates good nutritional status where as red fields presents an excessive content of leaf nitrogen (Spring et al. 2003). High water stress was measured with $\Psi_{predawn}$ at veraison. All values (Fig. 4) are over the irrigation threshold level of -3 bar (Schultz 2003). Chlorophyll Fluorescence parameter Fv/Fm before harvesting (maximum quantum efficiency of PSII) (Fig. 4) range from excellent to fair stress level (Mohammed et al. 2003). Chlorophyll fluorescence parameters showed no significant difference at within-plant variation of neighbour leaves in green house experiments (data not shown).

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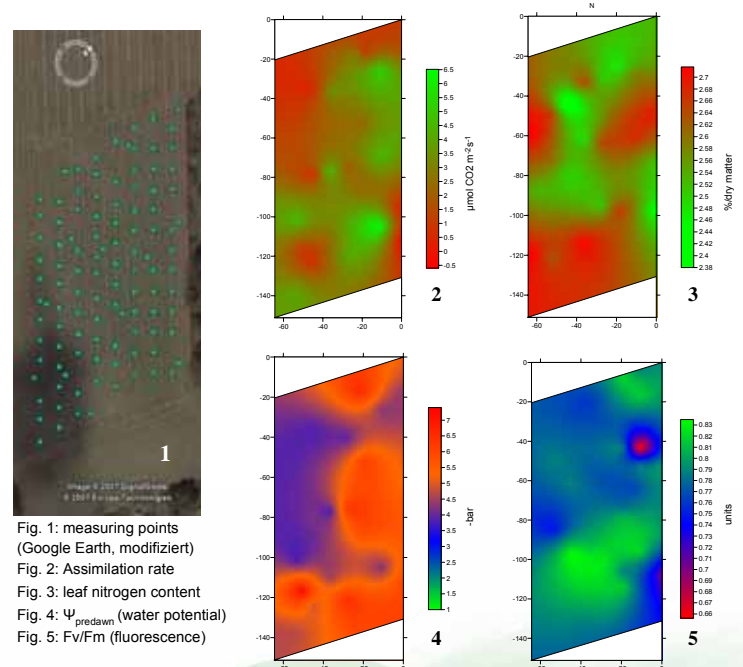


Fig. 1: measuring points (Google Earth, modifiziert)

Fig. 2: Assimilation rate

Fig. 3: leaf nitrogen content

Fig. 4: $\Psi_{predawn}$ (water potential)

Fig. 5: Fv/Fm (fluorescence)

	Assimilation	Leaf nitrogen	$\Psi_{predawn}$	Fv/Fm
Min	0.60	2.38	3.70	0.66
Mean	2.48	2.59	5.17	0.78
Max	6.51	2.72	8.28	0.83
Standard Deviation	1.131	0.06	0.791	0.021
Variance	1.279	0.003	0.625	0.0004
Coef. of Variance	0.456	0.023	0.153	0.027

Discussion

Data of vineyard showed spatial field variability found in gas exchange and chlorophyll fluorescence processes as well as in nutritional status (e.g. leaf nitrogen). Not all physiological parameters are suitable to detect spatial variability. Only parameters with stable, reproducible and significant attributes are appropriate. Also existing thresholds to determine stress status of plant species have to adapt to *Vitis vinifera* species and adjusted respectively. The correlation of physiological parameters with berry ingredients will carry out in further analysis.

References

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