Gradus Vol 12, No 1 (2025)
ISSN 2064-8014

THE EFFECT OF FOLIAR APPLICATIONS ON THE GRAPEVINE (*VITIS VINIFERA* L.) LEAF CHLOROPHYLL CONTENT AND LIGHT TRANSMITTANCE - PRELIMINARY RESULTS

Péter Bodor-Pesti[1] 0000-0001-8346-4975, Zsófia Schnörch 0009-0005-1679-2676 1, Krisztina Németh[1] 0000-0002-5208-1485, Attila Hüvely[2] 0000-0002-1498-2610, Gyula Váradi[2] 0000-0002-7918-5524, Tamás Deák[1] 0000-0001-8172-3259, Zsuzsanna Varga[1] 0000-0002-8371-6623, Luca Masiero[3] 0009-0008-0262-6556 and Diána Ágnes Nyitrainé Sárdy[1] 0000-0002-9394-2691*

[1] Institute for Viticulture and Oenology, Hungarian University of Agriculture and Life Sciences
[2] Department of Horticulture, Faculty of Horticulture and Rural Development, University of John von Neumann, Hungary
[3] Council for Agricultural Research and Agricultural Economy Analysis, CREA, Viticulture Research Centre (Conegliano TV)
https://doi.org/10.47833/2025.1.AGR.011

Keywords:
foliar application, leaf thickness, transmittance, chlorophyll content

Article history:
Received 6 February 2025
Revised 3 April 2025
Accepted 10 April 2025

Abstract
In this study, the effect of different foliar applications on the grapevine (Vitis vinifera L. cv. Riesling) leaf morphology was investigated. Leaf chlorophyll content was measured with an Apogee MC100 portable chlorophyllmeter, leaf thickness was investigated with a thickness gauge while the light transmittance was evaluated with a smartphone application running on a Xiaomi Redmi Note 9. Results showed that foliar applications have a significant effect on the leaf morphological traits. According to the correlation analysis of pooled samples, there is no significant relation between the monitored parameters. Interestingly if samples are split according to the applied treatments, we found a correlation between the measured traits that highlight the impact of the foliar application on the morphological characteristics. Our present research demonstrates that smartphones can be effectively integrated into agricultural studies and provide data that can complement observations.

1 Introduction

Grapevine (*Vitis vinifera* L.) morphological description is based on a set of traits defined in various literatures such as ampelographic albums [1-2], international descriptor lists [3], and scientific literature [4]. These traits have multiple importance in the identification of the genotypes and in the description of the effect of different cultivation practices on the canopy characteristics, individual leaf morphology, bunch architecture, and berry morphology. Among the organs leaf morphology is the most informative. On one hand it has the higher numbers of the traits involved in the identification, on the other hand leaf is the cornerstone of photosynthesis and transpiration, moreover, it significantly modifies canopy microclimate. Therefore, understanding factors that influence the size, shape and lobature moreover anatomy of the lamina is essential.

There is a high diversity among the genotypes in leaf morphology and morphometry [5]. This variability is further enhanced by environmental factors and yearly cultivation practices. Chitwood et

* Corresponding author.
E-mail address: Bodor-Pesti.Peter@uni-mate.hu

al. showed that climatic conditions have a noticeable effect on the leaf morphometry [6]. Bodor et al. reported that topography and structural elements of the vineyard in more particular elevation and row orientation also influence the leaf traits [7]. Concerning the maintenance practices, for example pruning level and nutrient supply can also influence the lamina characteristics.

Amont the cultivation practices foliar applications are frequently used to stimulate plant immune response, increase stress tolerance and improve grape and wine composition. For example, Ferrara and Brunetti (2008) applied humic acid in their research aimed to investigate the effect on the chlorophyll content, titrable acidity, soluble sugars, pH and yield. In accordance with former studies, caused by the treatments the authors reported increased chlorophyll content [8]. A more particular study about the effect of humic acid foliar application on the leaf morphology was reported by Popescu and Popescu (2018). They found significant differences in total leaf area and leaf fresh weight, while the leaf dry weight was not influenced by the treatments [9].

Canopy microclimate in more particularly radiation, humidity, temperature and wind directly influences physiology, yield and quality. Grapevine is considered a moderately light-demanding plant, which can grow well in a semi-shaded environment. Canopy light conditions are largely determined by the radiation, vineyard structure (e.g.: row orientation), canopy structure (e.g. numbers and density of shoots) and individual leaf morphology. Self-shading occurs when the numbers of shoots increase to a certain level when the leaf layers behind each other are high [10]. There are several methods and devices to get information about the canopy structure and light conditions inside the foliage such as the point quadrat method [11], using ceptometers [12], or smartphone applications such as the VitiCanopy [13].

Smartphones are important tools in precision agriculture for everyday operations, and there use in research is also important. Integrated tools of smartphones such as gyroscope, RGB camera, GPS, internet access, ambient light detectors provide the possibility of enhanced farm management operations, remote sensing, moreover geotagging and phenotyping [14]. Recently Dutta introduced the pros and cons of the RGB camera, which is one of the most important sensor involved in phenotyping, identification of diseases and predicting chemical composition. According to the author besides the RGB camera ambient light sensor (ALS) is a valuable tool for example in immunoblotting, for ELISA test moreover in environmental water quality monitoring [15]. Ospino-Villalba et al. designed a device with a light emitter to predict leaf chlorophyll according to the ALS [16]. Their results highlight the potential of ALS in research and suggest further possibilities in precision agriculture.

This preliminary study aimed to to investigate the effect of different plant foliar sprays on the leaf morphological characteristics, chlorophyll concentration and light transmittance of the ‘Riesling’ grapevine cultivar.

2 Materials and methods

2.1 Plant material

The experiment was set up in the Research Station for Viticulture and Oenology Kecskemét of the Hungarian University of Agriculture and Life Sciences. The investigated grapevine (*Vitis vinifera* L.) cultivar was Riesling. Leaf samples were collected at the beginning of September 2024. Fifteen leaves from at least 10 plants were collected from each treatment. Samples were stored in plastic bags and a cooling box until the measurements.

2.2 Treatments

During the vegetation period the following treatments were applied:

- C – control: In the control area we treated the vineyard according to the rules of the Agri-environment program without nutrient supplementation.
- AS - Active start technology: Active start is a 100% natural bioactivator made from extracts of plant materials, which contains amino acids and microelements essential for physiological processes in a natural form. Thanks to its antioxidant content, it reduces oxidative processes

and slows down aging processes. It contains silicon in an organic form, the faster incorporation of which promotes the plant's resistance to drought. The treatment was applied on the experimental plot for 2 consecutive years.

-
- PLHU – The research field plantation has been subjected to biological control since 2016. 3,5% methyl-salicylate was the main element of plant protection treatments with added Copper, Zinc, Sulfur, and potassium hydrogen bicarbonate. The number of treatments depends on the weather conditions. Orange oil was added to the sprays as an adhesion promoter. To increase the yield and quality, we used humic and fulvic acid + microelement supplements. The treatment was applied on the experimental plot for 8 consecutive years.
- DrG – The research field plantation has been subjected to biological control since 2016. To increase the yield and quality, we used Dr Green's technology foliar fertilizer formulations (Start, Energy, Quality). The treatment was applied on the experimental plot for 3 consecutive years.

2.3 Investigations

Leaf samples were washed and dried with absorbent wipes. From each leaf lamina, discs of equal size were cut (r = 10 mm; A = 314.2 mm^2). The chlorophyll content of each disc was recorded with a portable chlorophyll meter (Apogee MC100). The thickness of the discs was measured with a Moore & Wright thickness gauge. The leaf lamina transmittance was investigated with the Luxmeter application obtained on a Xiaomi Redmi note 9. Light conditions were standardized with a Nan-lite Compac 20-as ledpanel adott (ta=45°C/113°F. Color Temperature: 5600K, Guangdong NanGuang Photo &Video Systems Co. Ltd., China). The leaf discs were placed on the ambient light detector of the smartphone and the transmitted light was recorded in lux. The reference light was 12300 lux.

2.4 Statistical evaluation

The effect of the treatments on the leaf morphological traits were evaluated with ANOVA, while the correlation between the traits was investigated with Pearson's correlation. Statistical evaluation was carried out in PAST (version 4.17c) [17].

3 Results and Discussion

The results of this study showed that foliar spray applications had a significant effect on the grapevine leaf morphological traits (Figure 1). The lowest chlorophyll concentration was obtained in the case of DrG. (285.54 $\mu mol/m^2$), while the highest in the case of C and PLHU (378.21 $\mu mol/m^2$ and 378.13 $\mu mol/m^2$ respectively). The coefficient of variability ranged from 8.84% to 12.56% (C and DrG respectively). These data are in accordance with former studies. For example, Gutiérrez-Gamboa et al. showed that foliar applications such as different nitrogen sources and elicitors significantly influenced the chlorophyll and β-carotene concentration [18]. However the results showed that the effect depends on the cultivar to which the treatment applied. Later Al-Atrushy reported increased chlorophyll concentration (SPAD values) because of increased micronutrient doses. [19] The study also points out that individual leaf morphology is also influenced by the applications. In contrast with these findings, in our study leaf lamina thickness was not significantly altered by the treatments. The lowest value was observed in the case of AS (0.38 mm), while the thickest samples were obtained from the PLHU samples (0.44 mm). The coefficient of variability was the highest in the case of the C samples where the value was 19.11%, while the most uniform samples belonged to the PLHU (13.83%).

Light transmittance was the highest in the case of the PLHU samples with 26.57%, while the lowest in the case of C (22.6%). The coefficient variability of this trait ranged from 6.36% (PLHU) to 12.06% (C). Canopy light conditions have a significant role in microclimatic parameters such as temperature and humidity. These factors could modify the plant physiology, phenological stages and growth. Yield, quality and chemical composition of the fruit are also linked to climatic conditions in several ways. According to Smart (cit. in Keller) the light conditions of the foliage are not uniform, which is largely influenced by self-shading as the individual leaves reflect (6%), absorb (85-90%) and transmit (4-9%) of incident light [20]. These values differ among the grapevine cultivars as leaf morphology traits affecting light absorbance/transmittance such as leaf thickness, density of prostrate hairs, and color depends greatly on the genotype. The result of our study highlights the effect of foliage applications on leaf morphology, which possibly has direct consequences on the light conditions within the canopy, which may modify ripening and berry composition as well.

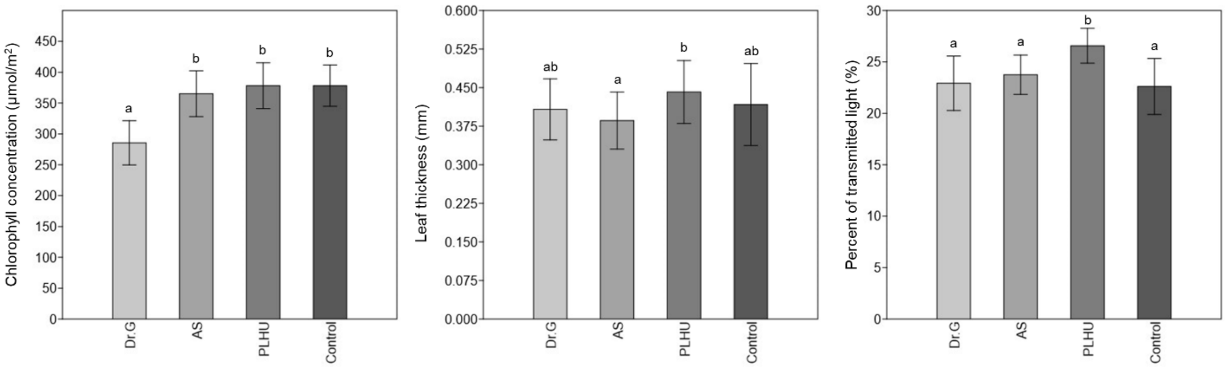

Figure 1. The effect of foliar applications on the leaf chlorophyll concentration (a), leaf thickness (b) and percent of transmitted light (c). Different letters indicate significant differences (p<0.05)

Pearson's correlation coefficient was calculated to find relationship between the investigated traits (*Table 1*). The correlation was investigated on the pooled samples (n=180) and on the samples obtained from each treatment (n=45). Results in the case of the pooled samples showed no significant correlation between the traits. Interestingly when the samples were grouped according to the treatments the correlation was significant in some cases. For example in the case of the DrG Leaf thickness and the Percent of transmitted light showed a significant negative correlation (r = -0.65; p < 0.01). In the case of the AS samples, also a significant negative correlation (r = -0.3962; p < 0.01) was obtained between the % of transmitted light and chlorophyll concentration. The relationship between the monitored traits was the strongest in the case of the control samples, where the chlorophyll concentration had a significant positive correlation with leaf thickness (r = 0.4067; p < 0.01), while a negative correlation to the % of light transmitted through the leaf lamina (r = -0.3945; p < 0.01).

Table 1. Pearson's correlation of the investigated parameters (p value above diagonal / significant correlation (r value) below diagonal)

Sample set		*Chlorophyll conc.*	*Leaf thickness*	*% of transmitted light*
Pooled samples	*Chlorophyll conc.*		x	x
	Leaf thickness	x		x
	% of transmitted light	x	x	
DRG	*Chlorophyll conc.*		x	x
	Leaf thickness	x		>0.01
	% of transmitted light	x	-0,65168	
AS	*Chlorophyll conc.*		x	>0.01
	Leaf thickness	x		x
	% of transmitted light	-0,39622	x	
PLHU	*Chlorophyll conc.*		x	x
	Leaf thickness	x		x
	% of transmitted light	x	x	
Control	*Chlorophyll conc.*		>0.01	>0.01
	Leaf thickness	0,40678		x
	% of transmitted light	-0,39455	x	

4 Conclusion

In this study 3 different treatments were applied to the canopy of the Riesling grapevine cultivar to monitor the effect on the leaf morphology. Results showed that the treatments had a significant effect on chlorophyll concentration, leaf thickness and the percentage of transmitted light. These results suggest that treatments also affect canopy microclimate through morphological changes. This may be of particular importance for the ripening and the chemical composition of the fruit. The study also highlights the complementary role of smartphones in research and the valuable data they can provide.

Acknowledgment

This study was supported by the Agri-Digital Growth Central Europe Interreg Project (CE0200761).

References

[**Error! No sequence specified.**] Viala, P., Vermorel V.: Ampelographie. Traite General de Viticulture: Ampélographie. Paris: Masson et Cie, 1901-1910. Seven volumes.
[2] Robinson, J., Harding, J., Vouillamoz, J.: Wine grapes: a complete guide to 1,368 vine varieties, including their origins and flavours. 2013, Vol. 8. Issue 1, pp. 106-109, Penguin UK. DOI: https://doi.org/10.1017/jwe.2013.9
[3] OIV: OIV Descriptor List for Grape Varieties and Vitis Species, 2nd ed.; Office International de la Vigne et du Vin: Paris, France, 2009; p. 177.
[4] Chitwood, D. H., Ranjan, A., Martinez, C. C., Headland, L. R., Thiem, T., Kumar, R., ... & Sinha, N. R.: A modern ampelography: a genetic basis for leaf shape and venation patterning in grape. Plant physiology, 2014, vol. *164* No. 1, pp. 259-272. DOI: https://doi.org/10.1104/pp.113.229708
[5] Preinier, D., Safner, T., Karoglan Kontić, J., Marković, Z., Šimon, S., Maletić, E.: Analysis of phyllometric parameters efficiency in discrimination of Croatian native V. vinifera cultivars. Vitis, 2014, Vol. *53*, pp. 215–217.
[6] Chitwood, D.H.; Rundell, S.M.; Li, D.Y.; Woodford, Q.L.; Yu, T.T.; Lopez, J.R.; Greenblatt, D.; Kang, J.; Londo, J.P. Climate and developmental plasticity: Interannual variability in grapevine leaf morphology. Plant Physiol*.* 2016, 170, 1480–1491. DOI: https://doi.org/10.1104/pp.15.01825
[7] Bodor, P.; Baranyai, L.; Parrag, V.; Bisztray, G.D. Effect of row orientation and elevation on leaf morphology of grapevine (Vitis vinifera L.) c.v. Furmint. Progr. Agric. Eng. Sci., 2014, 10, 53–69. DOI: https://doi.org/10.1556/progress.10.2014.4
[8] Ferrara, G.; Brunetti, G. Influence of foliar applications of humic acids on yield and fruit quality of table grape cv. Itália. *OENO One*, 2008, 42(2), 79-87.
[9] Popescu, G. C.; Popescu, M. Yield, berry quality and physiological response of grapevine to foliar humic acid application. Bragantia, 2018, *77*, 273-282.
[10] Smart, R. E. Principles of grapevine canopy microclimate manipulation with implications for yield and quality. A review. American Journal of Enology and Viticulture, 1985, 36(3), 230-239. DOI: 10.5344/ajev.1985.36.3.230
[11] Poni, S., Rebucci, B., Magnanini, E., & Intrieri, C. Preliminary results on the use of a modified point quadrat method for estimating canopy structure of grapevine training systems. Vitis, 1996, 35(1), 23-28. DOI: 10.17660/ActaHortic.1999.493.14
[12] López-Lozano, R., Casterad, M. A. Comparison of different protocols for indirect measurement of leaf area index with ceptometers in vertically trained vineyards. Australian Journal of Grape and Wine Research, 2013, 19(1), 116-122. DOI: https://doi.org/10.1111/ajgw.12005
[13] De Bei, R., Fuentes, S., Gilliham, M., Tyerman, S., Edwards, E., Bianchini, N., Collins, C. VitiCanopy: A free computer App to estimate canopy vigor and porosity for grapevine. Sensors, 2016, 16(4), 585. DOI: https://doi.org/10.3390/s16040585
[14] Mendes, J., Pinho, T. M., Neves dos Santos, F., Sousa, J. J., Peres, E., Boaventura-Cunha, J., Morais, R. Smartphone applications targeting precision agriculture practices—A systematic review. Agronomy, 2020, 10(6), 855. DOI: https://doi.org/10.3390/agronomy10060855
[15] Dutta, S. Point of care sensing and biosensing using ambient light sensor of smartphone: Critical review. TrAC Trends in Analytical Chemistry, 2019,110, pp. 393-400. DOI: https://doi.org/10.1016/j.trac.2018.11.014
[16] Ospino-Villalba, K., Gaviria, D., Pineda, D., & Pérez, J. A 3D-Printable smartphone accessory for plant leaf chlorophyll measurement. HardwareX, 2024, 20, e00597. DOI: https://doi.org/10.1016/j.ohx.2024.e00597
[17] Hammer, Ø.; Harper, D. A. Past: paleontological statistics software package for educaton and data analysis. Palaeontologia electronica, 2001, 4(1), 1. DOI: 10.1002/9780470750711
[18] Gutiérrez-Gamboa, G., Marín-San Román, S., Jofré, V., Rubio-Bretón, P., Pérez-Álvarez, E. P., Garde-Cerdán, T. Effects on chlorophyll and carotenoid contents in different grape varieties (Vitis vinifera L.) after nitrogen and elicitor

foliar applications to the vineyard. Food Chemistry, 2018, 269, pp. 380-386. DOI: https://doi.org/10.1016/j.foodchem.2018.07.019

[19] Al-Atrushy, S. M. Effect of foliar application of micronutrients and canopy management on yield and quality of grapevine (Vitis vinfera L) cv. Mirane. Iraqi Journal of Agricultural Sciences. 2019, 1029:50(2):626-637. DOI: https://doi.org/10.36103/ijas.v52i4.1410

[20] Keller, M. The science of grapevines. Academic press. 2020, p. 554. ISBN: 9780128163658