COMPARISON OF NDVI INDEX IN VINE WITH THE APPLICATION OF DIFFERENT CHEMICAL TREATMENTS[1]

Irina Marina Stević[2], Biljana Bošković[3], Danijela Živojinović[4], *Nevena Stevanović[5], Nikola Stanković[6], Maša Buđen [7]*

Abstract

This paper investigates the impact of various chemical treatments (organic and conventional) on the values of the NDVI index (Normalized Difference Vegetation Index) in grapevines. NDVI is used as a reliable indicator of plant health and vitality. By analyzing vegetative changes, it allows for the identification of differences between protection methods. The research included an analysis of a vineyard treated with organic and conventional preparations at two intervals after spraying. The results showed that the index values in areas treated with the organic preparation 30 days after spraying had high values. This finding suggests that the application of organic treatments plays multiple roles, contributing to sustainable agriculture while also impacting fruit quality. Therefore, the application of the NDVI index can be highly beneficial in assessing the effectiveness of different chemical treatments used in vineyards, thereby positively influencing vineyard management strategies.

Key words: *vegetation indices, NDVI index, vines, organic, conventional.*

1 Paper is a part of research financed by the MSTDI RS, agreed in decision no. 451-03-66/2024-03/200009 from 5.2.2024.

2 Irina Marina Stević, MSc, Research Trainee Institute of Agricultural Economics, Volgina 15, 11060 Belgrade, Serbia, ORCID 0000-0002-5894-363X Phone: +381116972858, e-mail: irina_m@iep.bg.ac.rs

3 Biljana Bošković Msc, Faculty of agriculture, Nemanjina 6, 11080 Belgrade, Serbia, ORCID 0000-0003-4977-3170 Phone +381114413555, e mail: biljanaboskovic24@gmail.com

4 Danijela Živojinović, MSc, Center for Viticulture and Oenology, Kolonija 6, 18116 Niš, Serbia, Phone +381184541128, e mail: cevvin.danijela@gmail.com

5 Nevena Stevanović, MSc, Research Trainee BioSense Institute, Dr Zorana Đinđića 1, 21000 Novi Sad, Serbia, ORCID 0000-0002-1613-7509 Phone: +381214852137, e mail: nstevanovic445@gmail.com

6 Nikola Stanković, MSc, Research Trainee BioSense Institute, Dr Zorana Đinđića 1, 21000 Novi Sad, Serbia, ORCID 0000-0002-8601-8070 Phone: +381214852137, e mail: nikola.stankovic@biosense.rs

7 Maša Buđen, MSc, Research Trainee BioSense Institute, Dr Zorana Đinđića 1, 21000 Novi Sad, Serbia, ORCID 0000-0003-3825-5888 Phone: +381214852137 , e mail: bmasha95@gmail.com

Introduction

The vine (Vitis vinifera) is a plant from the Vitaceae family. Today's grapevine production, both in the Republic of Serbia and in the world, represents a highly developed branch of agriculture. Thanks to adequate conditions, a moderate climate and fertile soil, the production of numerous varieties of vines is possible. The vine is primarily grown for the production of grapes, so it is possible to obtain wines from the highest quality to lower quality table wines. According to the latest data in 2023, the area under vineyards was 18,349 ha(MPŠV, 2023).

Recently, great importance has been given to organic agricultural production in viticulture and their development is encouraged in areas where there was no intensive agriculture, in fact in unpolluted nature conditions (Gvozdenović et al., 2007; Korać et al, 2011; Korać et al, 2016 Willer, 2008).

The digitization of agriculture has contributed to the rapid development of new technologies for monitoring agricultural production, and thus the introduction of the concept of precision viticulture began. Precision agriculture (PA) can often help maximize yield while reducing resource use to minimize losses. Thus, PA can reduce variability and input costs (Cisternas et al., 2020).

Precision viticulture enables adequate management of production within the vineyard with the help of new technologies, which enable data collection. By further analyzing the collected data with a high level of accuracy, better quality decisions can be made in the management of viticulture production. (Rendulić Jelušić et al., 2020).

In order to further improve crop condition monitoring and increase yields, research based on remote sensing is increasingly being used today, which can be extremely important when making decisions in crop management. (Muruganantham, et al., 2022; Stevanović et al., 2024). The processing of data collected by remote sensing, using sensors, enables the calculation of vegetation indexes. These indexes provide the possibility of calculating simple algorithms for quantitative and qualitative analysis of vegetation cover, vitality and growth dynamics (Xue & Su, 2017).

The most commonly used vegetation indexes in viticulture are:

- NDVI (*Normalised Difference Vegetative Index*) - the most commonly used vegetation index for determining vegetation characteristics and monitoring growth and lushness (Xue i Su, 2017; Matese & Di Cenn-

aro, (2021). It represents the ratio between the near infrared (NIR) and the visible red part of the spectrum (R) that plants reflect.

- GNDVI (*Green Normalised Difference Vegetative Index*) - uses the green channel (G) instead of red because green has been shown to be more sensitive to chlorophyll than the red part of the spectrum and the near-infrared (NIR) part of the electromagnetic spectrum (Mwinuka et al., 2021; Ferro et al., 2023)
- SAVI *(Soil Adjusted Vegetation Index*) - this index also uses a soil adjustment factor (L) (Huete, 1988; Ren et al., 2018). This index is very important when monitoring the condition of vegetation with less vigor or in the initial stages when it is necessary to remove the influence of soil reflection.
- NDRE (*Normalized Difference Red Edge Index*) - indicates the chlorophyll content in the plant. Unlike the NDVI index, which observes the values of "greenness" only on the upper parts of the plant, this index penetrates to lower levels, so there can be a significant difference in values, especially in taller and denser crops. (Ferro et al., 2023).

Material and method

The experiment was monitored in the vineyard of the Agricultural School with the home of students "Sonja Marinković" in Požarevac, in the 2024 production year. The data obtained were taken from four repeated experiment, the vines of the "gama" variety were recorded in three terms

1. Control recording before chemical protection
2. First recording after chemical protection - 15 days after spraying
3. Second recording after chemical protection - 30 days after spraying.

Chemical protection was carried out using a conventional crop protection chemics (*Orvego* 2ml/100 l vode) and organic crop protection chemics (*Fitomil l60* 50ml/10l vode). Chemical protection was implemented against blight.

From each repetition, the values of the following index were calculated:

$$NDVI = \left(\frac{NIR-RED}{NIR+RED}\right)$$ (Wang et al., 2022)

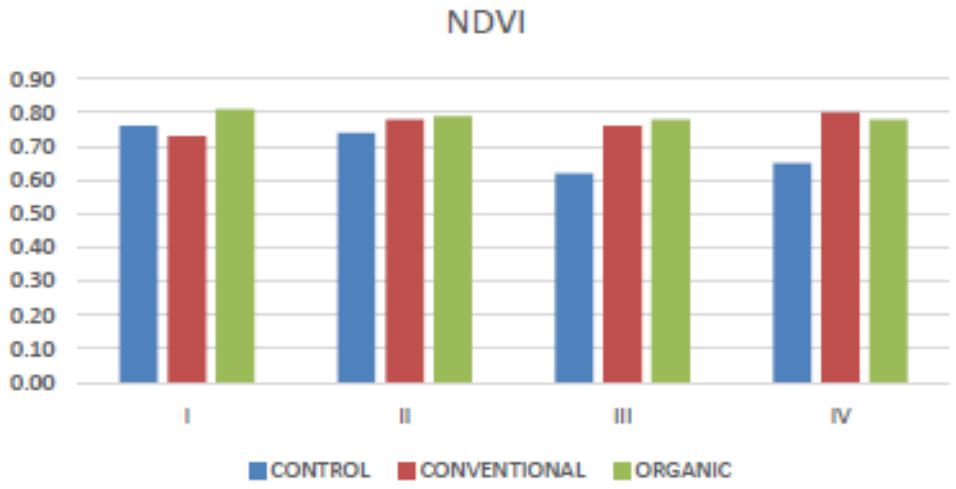
Three treatments of grapevines were observed, which were treated: with a conventional crop protection chemics, an organic crop protection chemics, as well as a treatment that was not treated with chemical crop protection chemics (control). The value of the vegetation indexes was obtained using a hand-held, proximal multispectral sensor, called a plantometer.

"Plant-O-Meter", this sensor allows the calculation of more than 30 vegetation indices. It uses six optical channels (https://www.plant-o-meter.com/): blue (wavelength 455 nm), green (wavelength 528 nm), red (wavelength 657 nm), red edge (wavelength 740 nm), near-infrared 1 – "NIR1" (wavelength 810 nm), and near-infrared 2 – "NIR2" (wavelength 940 nm)

Results and discussion

The control recording was carried out before the application of chemical protection on the same day, June 15, 2024. The values of the NDVI index are shown in the following graph (Graph 1.).

Graph 1. *NDVI index values before chemical protection*

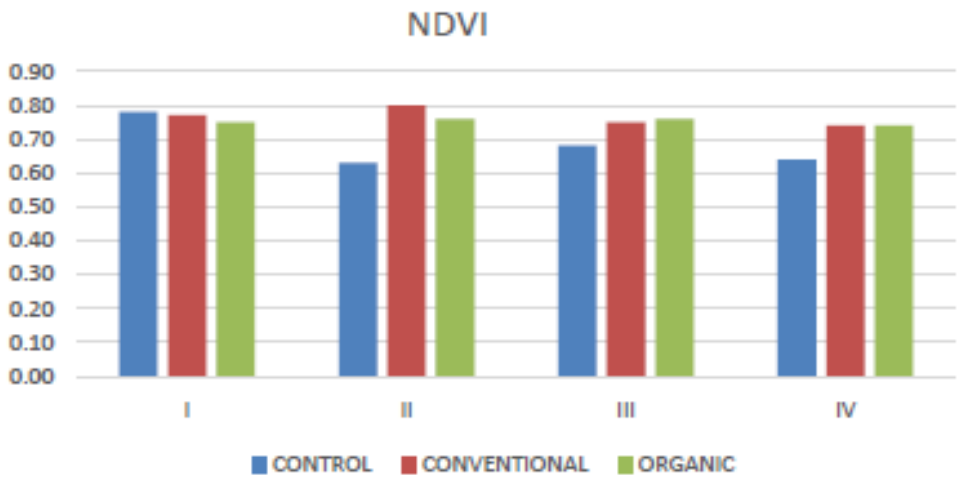


Source: *According to authors calculations*

The values of the NDVI index in the I and II repetition showed minimal differences, while in the IV and III (0.62) repetition it is clearly seen that the value of the index even before the protection itself in the control part has lower values.

The next recording, which was carried out 15 days after the application of different crop protection chemics for chemical protection, showed greater differences compared to the first recording. The values of the NDVI index are shown in the following graph (Graph 2.)

Graph 2. *NDVI index values - first recording after chemical protection*

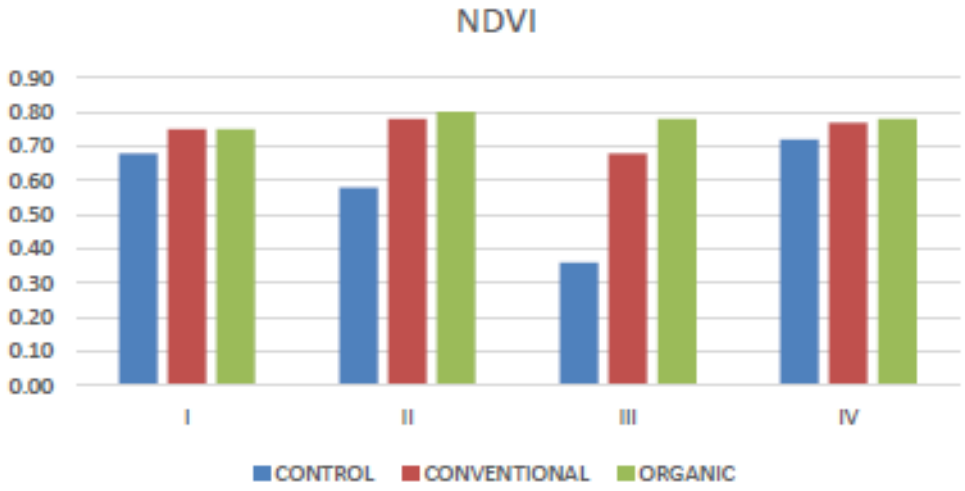


***Source**: According to authors calculations*

The values of the NDVI index of the control part only in the first repetition had higher values (0.78) than the treated coppices (0.77 and 0.75). In the II repeat, the value of the NDVI index was the best for the conventionally treated coppices (0.8), while in III and IV the indices of the treated coppices were very similar and even.

The third recording was performed 30 days after the application of chemical protection and based on the calculated values the following conclusions were established. The values of the NDVI index (Graph. 3) after the application of organic preparations in three repetitions have the highest value (II repetition 0.8).

Graph 3. *NDVI index values - second recording after chemical protection*



Source: *According to authors calculations*

The importance of the application of chemical protection is clearly seen because the NDVI index values of untreated shoots are significantly lower, the biggest difference is noticeable in the III repetition where the value of the index of untreated shoots is 0.36 and organically treated 0.78).

At the same time, the importance of the application of organic preparations, because the highest values are observed in the parts treated with organic preparations.

Conclusion and recommendations

Observing the results obtained regarding the effects of conventional and organic preparations, it is important to mention that conventional preparations often have a faster and more intense effect on pest control, but they can cause stress in plants and thus reduce the process of photosynthesis, which directly affects the reduction of the NDVI index value. These spills can have lasting consequences and a negative impact on the ecosystem. On the other hand, organic preparations consisting of natural substances have less impact on the environment. The use of such preparations often leads to minor damage to the plants themselves, thus the recovery is shorter, and the photosynthetic activity is stronger. All this is reflected by higher values of the NDVI index.

The NDVI index proved to be a good indicator of the condition of the plant after the application of both types of protection, because it provides an objective picture and thus favors the application of organic preparations in order to achieve sustainable, environmentally acceptable and healthy agricultural practices.

Acknowledgements

Paper is a part of research financed by the MSTDI RS, agreed in decision no. 451-03-66/2024-03/200009 from 5.2.2024.

Literature

1. Cisternas, I., Velásquez, I., Caro, A., & Rodríguez, A. (2020). Systematic literature review of implementations of precision agriculture. *Computers and Electronics in Agriculture*, *176*, 105626.
2. Ferro, M. V., Catania, P., Miccichè, D., Pisciotta, A., Vallone, M., & Orlando, S. (2023). Assessment of vineyard vigour and yield spatio-temporal variability based on UAV high resolution multispectral images. *biosystems engineering*, *231*, 36-56.
3. Gvozdenović D., Dulić Kata, Injac M., Ubavić M., Đukić N., Moldovan S., Petrina Ruţa (2007): Gusta sadnja jabuke, kruške i dunje – integralni concept. Prometej, Novi Sad.
4. https://www.plant-o-meter.com/
5. Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote sensing of environment*, *25*(3), 295-309.
6. Korać, N., Cindrić, P., Medić, M., Ivanišević, D. (2016) Voćarstvo i vinogradarstvo, Univerzitet u Novom Sadu, Poljoprivreni fakultet.
7. Korać, N., Ivanišević, D., Popov, M. (2011) Organsko vinogradarstvo. Zadužbina Andrejević, Beograd
8. Matese, A., & Di Gennaro, S. F. (2021). Beyond the traditional NDVI index as a key factor to mainstream the use of UAV in precision viticulture. *Scientific Reports*, *11*(1), 2721.

9. Ministarstvo poljoprivrede, vodoprivrede i šumarstva (2023). Izveštaj o stanju u poljoprivredi u Republici Srbiji u 2023.godini, Izveštaj o stanju u poljoprivredi u republici Srbiji u 2023. godini. Knjiga II

10. Muruganantham, P., Wibowo, S., Grandhi, S., Samrat, N. H., & Islam, N. (2022). A systematic literature review on crop yield prediction with deep learning and remote sensing. Remote Sensing, 14(9), 1990.

11. Mwinuka, P. R., Mbilinyi, B. P., Mbungu, W. B., Mourice, S. K., Mahoo, H. F., & Schmitter, P. (2021). The feasibility of hand-held thermal and UAV-based multispectral imaging for canopy water status assessment and yield prediction of irrigated African eggplant (Solanum aethopicum L). Agricultural Water Management, 245, 106584

12. Ren, H., Zhou, G., & Zhang, F. (2018). Using negative soil adjustment factor in soil-adjusted vegetation index (SAVI) for aboveground living biomass estimation in arid grasslands. *Remote Sensing of Environment, 209*, 439-445.

13. Rendulić Jelušić, I., Anić, M., Puhelek, I., Osrečak, M., Šakić Bobić, B., Grgić, Z., Karoglan, M. (2020). Pregled novih tehnologija za praćenje vinogradarske proizvodnje i primjenu preciznog vinogradarstva. In: Zbornik radova 55. hrvatski i 15. međunarodni simpozij agronoma, Sveučilište u Zagrebu, Agronomski fakultet, Zagreb, Hrvatska, pp. 510-514

14. Stevanović, N., Stanković, N., Ljubičić, N., Vukosavljev, M., Lipovac, A., Marina, I., & Stričević, R. Korišćenje ručnog multispektralnog senzora i bespilotne letelice u praćenju razvoja i produktivnosti soje u prirodnim uslovima vlaženja.

15. Wang, N., Guo, Y., Wei, X., Zhou, M., Wang, H., & Bai, Y. (2022). UAV-based remote sensing using visible and multispectral indices for the estimation of vegetation cover in an oasis of a desert. Ecological Indicators, 141, 109155.

16. Willer Helga (2008): Organic viticulture in Europe. Development and current statistics. 16 th IFOAM Organic World Congress, 2008

17. Xue, J., & Su, B. (2017). Significant remote sensing vegetation indices: A review of developments and applications. Journal of sensors, 2017.