Smart Irrigation and Water Management Strategies in Eastern European Viticulture

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Keywords: climate change, viticulture, Eastern Europe, smart irrigation, water stress

Abstract

The objective of this study was to synthesize and analyze the impact of climate change on viticulture in Eastern Europe by assessing the phenological advance, grape quality and production, as well as the onset and intensification of water stress in the wine-growing regions of Romania, Bulgaria, Hungary, Poland and the Republic of Moldova. In parallel, based on scientific articles and regional reports published to date, the study aimed to update data on the evaluation of modern irrigation technologies and smart water management approaches, such as Research, Development and Innovation (RDI), real-time monitoring and automated systems, as well as integrating the relevant Europeanand national legislative framework to highlight how current regulations support the adoptionof these solutions. The article is based on a systematic review of scientific literature publishedmainly in the last decade, the selection being supported by a bibliometric analysis performedin the Web of Science database, to identify the main research trends and relevant contributionson the impact of climate change on viticulture and water management strategies in EasternEurope. Regional data reported so far have shown a 1 to 3-week phenological shift in Romania (Iași, Ștefănești, Oltenia, Târnave), accompanied by increased sugar concentrations (+15–25g/L) and reduced total acidity. In Bulgaria and Hungary, similar patterns were associated witha shortened growing season and the need for intensified irrigation. In Poland, climate warmingallowed the expansion of viticulture to higher altitudes and more northern latitudes, butgenerated a significant water deficit in the period June-August, necessitating additionalirrigation. In the Republic of Moldova, the main wine-growing regions (Valul lui Traian,Codru) are strongly affected by drought and sugar-acid imbalances, leading to the adoption of computerized irrigation systems based on sensors and renewable energy sources. Modern irrigation in Eastern Europe is increasingly supported by sensor-based systems and renewable energy sources, providing the technological infrastructure necessary for the effective implementation of RDI. Regional data highlight the effective application of RDI in Romania (Dealu Mare, Valea Călugărească, Oltenia, Târnave), Hungary (Tata, Tokaj), Poland (vineyards affected by summer drought) and the Republic of Moldova (Valul lui Traian, Codru), where controlled water deficit contributed to improved grape quality and increased water use efficiency. In all five countries, RDI has been reported to have positive effects on sugar and phenolic content, berry quality and water use efficiency, without reducing yield when applied correctly. By updating the most relevant regional publications and integrating the results reported in recent studies, the article provides a comprehensive and up-to-date perspective on the main climate-related challenges facing Eastern European viticulture and on the irrigation technologies currently used, thus strengthening the knowledge base needed to develop sustainable climate change adaptation strategies.

Source of the abstract: Florea A.C., Sumedrea D.I., Rodino S., Ion M., Dragomir V., Dumitru A.-M., Pîrcalabu L., Dinu D.G. (2025). The Impact of Climate Change on Eastern European Viticulture: A Review of Smart Irrigation and Water Management Strategies. *Horticulturae*, 11(11), 1282. DOI: https://doi.org/10.3390/horticulturae11111282.