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# RELATIONSHIPS BETWEEN THE COMPONENT ELEMENTS OF THE ANTHROPIC VITICULTURAL ECOSYSTEM AND THEIR INFLUENCE ON GRAPE PRODUCTION UNDER THE SPECIFIC CONDITIONS OF S.D. BANU MĂRĂCINE

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## ABSTRACT

*The viticultural ecosystem is recognized as a complex and integrated agroecosystem, in which natural components - such as soil, climate, soil microfauna, spontaneous vegetation, and grapevine varieties - interact with anthropogenic factors in ways that fundamentally determine the quality and uniqueness of grape production. Any alteration within this complex system, whether naturally occurring or human-induced, can lead to significant differences in the composition, structure, quality, and quantity of the yield. Therefore, the viticultural ecosystem should not be regarded merely as a framework for production, but as a strategic component of sustainable viticultural technology. The results presented in this paper fall within this context, representing a stage in a broader study focused on the components of the viticultural ecosystem, the relationships among them, and their influence on grape production under the specific conditions of the Banu Mărăcine Didactic Research Station.*

## INTRODUCTION

Viticultural ecosystems embody the dynamic interaction between humans and nature, requiring both technological and adaptive responses to ensure sustainability and preserve viticultural heritage (Costea et al. 2023). Modern viticulture is structured as an anthropic ecosystem where ecological equilibrium and productivity are interdependent outcomes of interactions among soil, climate, biodiversity, grapevine varieties, and agrotechnical practices that together define the terroir (Bodin & Morlat 2006, Van Leeuwen & Seguin 2006, Cichi et al. 2024).

Climate change poses a major challenge, influencing vine physiology, productivity, and grape quality through rising temperatures and altered precipitation, thus necessitating adaptive vineyard management (Costea, 2006). Consequently, recent research emphasizes systemic approaches that integrate biotic and abiotic factors with technological practices to ensure sustainability and wine quality (Deloire et al. 2005, Jones et al. 2010, Mărăcineanu et al 2021, Costea et al., 2025).

Within this open agroecosystem, grapevines interact with a diverse biotic community—plants, fauna, and microorganisms—through mutualistic, neutral, or antagonistic relationships that shape vineyard health and ecological stability (Molitor et al. 2022). These interactions exemplify the continuous exchange of matter, energy, and information that sustains ecological systems (Neacșu et al. 2000).

This study contributes to this line of inquiry by analyzing the interrelations among components of the anthropic viticultural ecosystem and their effects on grape production under the specific conditions of the Banu Mărăcine Didactic Research Station, aiming to support sustainable vineyard management strategies

## MATERIAL AND METHODS

The observations and determinations were carried out within the vineyard of the Banu Mărăcine Didactic and Experimental Station, both in the adjacent area and in the plot cultivated with the Cabernet Sauvignon variety grafted onto SO4 rootstock. The vines were trained on a semi-high bilateral cordon system, with a load of 24 buds per vine, distributed on fruiting spurs of three buds each.

The research activities focused on: monitoring and assessing climatic factors; evaluating biodiversity within the vineyard ecosystem and identifying the main trophic categories; highlighting the role of biocenotic components in maintaining the balance of the vineyard ecosystem; assessing the performance of the Cabernet Sauvignon variety under the specific conditions of the Banu Mărăcine viticultural ecosystem, based on production quality parameters.

The research methods were adapted to the characteristics of the studied ecosystem and included analytical determinations for the study of biocoenotic structure, quantitative measurements for environmental factors, direct observations, systemic analysis to obtain an integrative view of the ecosystem, and experimental methods to evaluate the behavior of the Cabernet Sauvignon variety.

The combined use of these methods led to a comprehensive understanding of the complexity of the Banu Mărăcine vineyard ecosystem, its biodiversity, and the importance of sustainable natural resource management.

## RESULTS AND DISCUSSIONS

### *Assessment of climatic conditions*

The climatic data presented in figures 1–6 provide an integrated overview of meteorological variations recorded during the experimental period compared with multiannual climatic averages. Data were sourced from the online platform www.worldweatheronline.com ,which compiles records from a weather station located near the Craiova vineyard area, ensuring a reliable and context-specific characterization of local conditions.

*Air temperature*. Comparative analysis of multiannual averages (Figure 1) and annual mean air temperatures (Figure 2) reveals a general upward trend, with the most pronounced increase observed in July and August, when average temperatures were approximately 1 °C higher than the 2010–2023 multiannual mean. Such thermal deviations may accelerate phenological development and sugar accumulation in grape berries, potentially causing imbalances between sugar and acidity levels—parameters essential for oenological quality. Within the broader context of climate change, these shifts are expected to become more frequent, highlighting the necessity of adapting viticultural practices to preserve both technological and sensory stability in wine production.

*Precipitation regime*. According to figure 4, the experimental period showed an atypical rainfall pattern, with abundant precipitation early in the growing season (April–June 2024), followed by a marked decrease from August to October, coinciding with veraison and ripening. In the first half of 2025, precipitation increased again, generating pronounced hydrological variability. Compared with multiannual data (Figure 3), total rainfall was lower and unevenly distributed, as long-term trends indicate a higher rainfall concentration

between May and July. This irregular distribution may have induced water stress during critical phenological stages, potentially influencing growth dynamics, yield, and fruit quality.

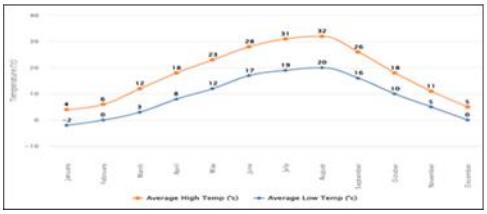

Fig. 1. Air temperature – Multiannual average values (2010–2023)

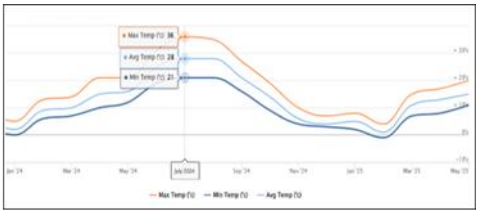

Fig 2. Air temperature-Monthly minim, maxim, and mean values in the experimental period

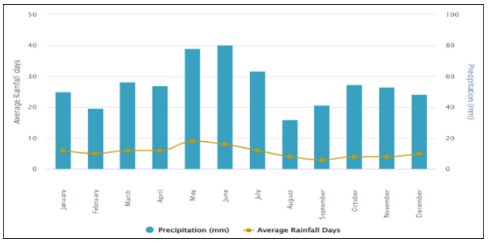

Fig.3. Precipitation and number of rainy days - Multiannual average values (2010–2023)

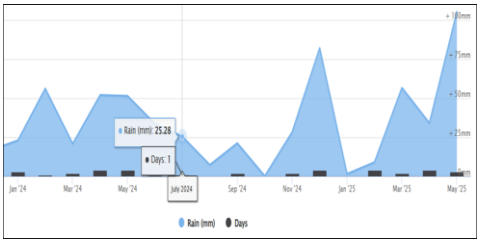

Figure 4. Monthly precipitation and number of days with rainfall in the experimental period

*Solar radiation*.As shown in Figures 5 and 6, solar radiation—an essential factor for photosynthesis, transpiration, and vegetative growth—remained relatively stable, with only minor deviations from multiannual averages. Nevertheless, slight seasonal variations may subtly influence vine phenology and secondary metabolite accumulation, which are relevant to must and wine composition.

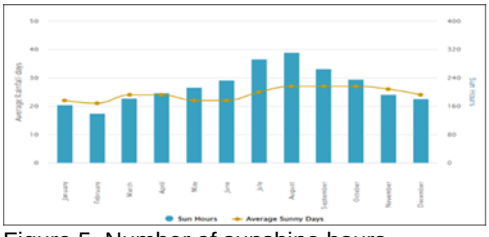

Figure 5. Number of sunshine hours – Multiannual values

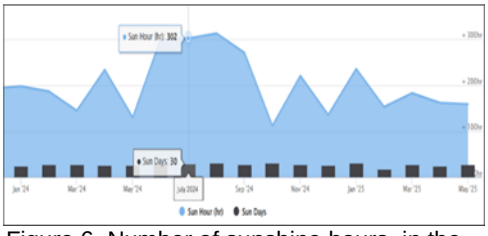

Figure 6. Number of sunshine hours in the experimental period

The combined variability of the main climatic factors-precipitation, solar radiation, and humidity-may have significant implications for vineyard ecosystems, including local biodiversity. Climatic conditions characterized by rising temperatures, uneven precipitation distribution, and fluctuations in solar radiation and atmospheric humidity can alter the ecological balance of the vineyard ecosystem, affecting vine physiological processes, productivity, crop quality, and associated biodiversity..

**Assessment of vineyard ecosystem biodiversity and highlighting the role of its components in maintaining ecological balance**

*Biodiversity monitoring within the Banu Mărăcine vineyard ecosystem* is a key instrument for assessing the ecological health of the agroecosystem and guiding sustainable viticultural practices. It involves the periodic identification and evaluation

of plant and animal diversity both within the vineyard and in adjacent areas, providing relevant indicators of ecological balance and trophic stability ( Figure 7).

*Beneficial flora identified in the Banu Mărăcine vineyard ecosystem* plays a crucial role in maintaining ecological equilibrium and reducing dependency on chemical inputs. Herbaceous and aromatic species such as *Trifolium repens* (white clover), *Matricaria chamomilla* (chamomile), *Phacelia tanacetifolia* (phacelia), *Calendula officinalis* (marigold), and *Viola tricolor* (wild pansy) contribute to soil fertility, nitrogen fixation, erosion control, microclimate regulation, and the attraction of pollinators and predatory insects. Their strategic integration supports resilient and ecologically balanced vineyard systems with minimal environmental impact.

*Beneficial fauna identified in the Banu Mărăcine vineyard ecosystem* encompasses a wide range of invertebrates, insectivorous birds, reptiles, amphibians, and small mammals that contribute to natural pest regulation. Earthworms (*Lumbricina*) act as bioindicators of soil health, predatory spiders (Salticidae) and beneficial insects such as *Coccinella septempunctata*, parasitoid wasps, and hoverflies (Syrphidae) ensure biological control of aphids and *Lobesia* moths. Insectivorous birds-*Dendrocopos syriacus*, *Fringilla coelebs*, *Turdus merula*, and *Cyanistes caeruleus*-together with lizards (*Lacerta agilis*), hedgehogs (*Erinaceus europaeus*), and bats (*Chiroptera*), complete the trophic web by reducing pest pressure on grapevines.

*Harmful fauna identified in the Banu Mărăcine vineyard ecosystem* includes phytophagous species such as *Tetranychus urticae* (common red spider mite), *Lobesia botrana* (European grapevine moth), *Melolontha melolontha* (May beetle), *Anomala vitis*, and *Eriophyes vitis* (grape erineum mite). These pests can cause significant damage to leaves, roots, and grape clusters or promote fungal infections under drought and high-temperature conditions.

Figure 7. Observations for biodiversity monitoring in the anthropic vineyard ecosystem (in detail: adults and larvae of Coccinella septempunctata and Syrphidae)

*The trophic structure of the Banu Mărăcine vineyard ecosystem* reveals a complex web of interactions among producers, consumers, and decomposers. The grapevine, as the primary producer, sustains communities of phytophagous and predatory species, while spontaneous floral diversity and natural vegetation enhance a balanced and resilient trophic network. Consequently, the adoption of a phytosanitary management system grounded in ecological agriculture principles - promoting biodiversity, biological control, and selective interventions - is fundamental for ensuring the long-term conservation and ecological integrity of the Banu Mărăcine vineyard ecosystem

***Analysis of the bioproductive parameters***

To evaluate the quantitative and qualitative development of grape production for the Cabernet Sauvignon cultivar under the viticultural ecosystem of Banu Mărăcine, the following parameters were monitored: the weight and volume of 100 berries, titratable acidity, and sugar content. The obtained data, graphically represented in the corresponding figures (Figures 8 and Figures 9), provide relevant insights for future technological decision-making.

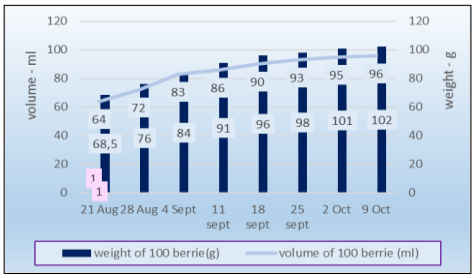


Figure 8 The dynamic evolution of the weight and volume of the berries during ripening

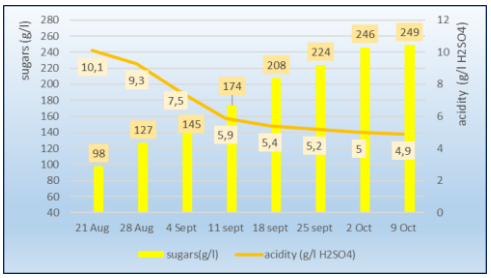


Figure 9 Evolution of sugar content and acidity of berries during maturation

Berry weight and volume were used as indicators of biomass accumulation and yield dynamics, whereas titratable acidity and sugar content reflected the degree of technological maturity and overall fruit quality.T he analysis of berry mass and volume between August 21 and October 9 showed a steady increase, reaching 102 g and 96 mL per 100 berries at full maturity ( Figure 8). During the same period, titratable acidity gradually decreased to 4.8 g/L $H_2SO_4$, while sugar concentration increased to 249 g/L, representing a gain of 151 g/L (Figure 9). These trends indicate an accelerated ripening process, positively influenced by the climatic conditions of 2024.

High temperatures, increased solar radiation, and reduced rainfall significantly affected physiological and metabolic processes, resulting in grapes of superior quality. The specific climatic context of 2024 led to the advancement of the harvest date by approximately 15 days compared to the multiannual average.

## CONCLUSIONS

The study conducted within the viticultural ecosystem of the Banu Mărăcine Didactic Station demonstrated that integrating sustainable development principles into vineyard management supports ecological balance and optimizes productive performance while preserving biodiversity.

The analysis of the Cabernet Sauvignon cultivar during the 2024 growing season—characterized by suboptimal climatic conditions—highlighted the resilience of the local viticultural ecosystem and its capacity to maintain production under variable environmental conditions.

These findings emphasize the importance of adopting a sustainability-oriented approach to viticulture, harmonizing human activity with natural processes to ensure long-term productivity, ecosystem health, and wine quality.

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