ANNALS OF THE UNIVERSITY OF CRAIOVA

Series: ✓*Biology*
✓*Horticulture*
✓*Food products processing technology*
✓*Environmental engineering*

Vol. XXX (LXVI) - 2025

THERMAL REGIME DURING THE 2025 GROWING SEASON IN THE BANU MĂRĂCINE VINE-GROWING AREA

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Keywords*: temperature, grapevine, growing season,*

ABSTRACT

This paper presents the results of a study conducted at the University of Craiova, Banu Mărăcine Educational Station, based on data provided by the weather station located in the vineyard. The results obtained show that the year 2025 was particularly warm, the average temperature in the period March 1 - September 30 being 2 ^{0}C higher than the average of a 90-year interval (1901 - 1990). The increase in the average temperature in the growing season was due to the summer months and September. This is particularly important because it corresponds to the grape ripening period, which influences not only the quantity but also the quality of grape production, namely the sugar content, acidity and aromas, favorable for obtaining high-quality wines.

INTRODUCTION

Viticulture is a worldwide agricultural sector with a relevant economic importance, especially in regions where the climate and environmental conditions meet requirements for the production of high quality wines. The impact of climate change combined with the increased frequency of extreme events predicted for the next future has already shown its potential detrimental effects on viticulture suitability, but few studies currently explored the effect of long-term climate change and extreme events by considering the inter-varietal variability of grapevine (Leolini et al 2018). Viticulture is tightly dependent on weather and climate. Over the centuries, winegrowers have adapted to climatic conditions and found the best practices to successfully grow vines in different geographical areas. However, this equilibrium between climate and viticulture could be challenged by climate change (Massano et al 2023). Climate change is affecting grape yield, composition and wine quality. As a result, the geography of wine production is changing. About 90% of traditional wine regions in coastal and lowland regions of Spain, Italy, Greece and southern California could be at risk of disappearing by the end of the century because of excessive drought and more frequent heatwaves with climate change. Warmer temperatures might increase suitability for other regions (Washington State, Oregon, Tasmania, northern France) and are driving the emergence of new wine regions, like the southern United Kingdom. The degree of these changes in suitability strongly depends on the level of temperature rise (van Leeuwen et al 2024).

Warming has two major effects on the wine industry: compressing harvest duration, thus stressing the current capacity of wineries to process more fruit in a

shorter time, and compromising fruit composition and wine style (Moran et al 2018). Recent increases in average air temperatures and heat wave intensity can present challenges in maintaining grape productivity and quality (Ponce de León & Bailey 2022). Climatic factors strongly affect grapevine productivity and quality. In recent decades, global temperature increases of over 2 °C above pre-industrial levels have impacted phenology, yield, sugar accumulation, and harvest time, ultimately affecting wine quality. Heat stress (> 35 °C) for 3–5 consecutive days from high temperatures and excessive solar radiation can disrupt the vine's physiology, prompting accelerated sugar accumulation in berries by 20–30 %, a consequence of multiple factors including berry dehydration and high alcohol concentrations that compromise wine quality and typicity (Kidanemaryam et al 2025).

Meteorological parameters have a crucial influence on grapevine (*Vitis vinifera* L.) production quantity and quality. Most of the commonly used bioclimatic indices are not appropriate to represent intravineyard micrometeorological variability, in particular the subdaily dynamics that are important in grape maturation processes. Indices based on subdaily data better provide a better representation of vineyard microclimate than daily indices and are able to highlight microclimatic differences induced by canopy management practices (Matese et al. 2012).

Weather conditions have a significant impact on crops, and temperature is one of the main factors that controls plant development. Thermal time models based on temperature have been applied to predict the development of many species (Zapata et al. 2017). The rise in air temperature due to climate change is causing an increase in the sugar accumulation rate in grape berries, resulting in increased wine alcohol concentrations (Caccavello et al 2019). Europe emerges as an especially responsive area to the temperature rise induced by climate change (CC), particularly during the warm season, while continuous warming is projected throughout the 21st century over the continent where negative impacts will predominate, including lower harvestable yields, higher yield variability and a reduction of the suitable areas for the cultivation of traditional crops. Apparently, in the context of the aforementioned climatic evolution, particular attention needs to be paid to prominent perennial crops which are typically grown in Europe where the growingseason mean temperatures already have increased by 1.7 °C from 1950 to 2004. Grapevine (*Vitis vinifera* L.) is included in this category given that it is largely recognised as one of the most important crops cultivated across Europe, playing a key socio-economic role (Droulia & Charalampopoulos 2021).

Climate resilience plays a critical role in determining the fruitfulness and yield of grapes, one of the most significant fruit crops globally. Grapevines are particularly sensitive to changes in climate, which can alter phenological stages, affect flowering, fruit set, and berry development, and ultimately influence yield and fruit quality (Malavika et al 2025).

MATERIAL AND METHODS

In this study, we followed the evolution of temperatures throughout the entire grape growing season (April 1 – September 30) in 2025 in the Banu Mărăcine wine area, Dealurile Craiovei vineyard. The meteorological data are provided by the weather station located in the vineyard, which is integrated into the vineyard's drip irrigation system. Every day, temperature values were recorded 8 times, every 3 hours (0.00, 3.00, 6.00, 9.00, 12.00, 15.00, 18.00 and 21.00) and based on them,

the average daily temperature was calculated, and based on this, the sum and average of the monthly temperatures for the entire growing season.

The recorded temperature values and the indices calculated based on them for the year 2025 were compared with the multiannual average values calculated for a 90-year period (1901–1990), taken from the ANM archive.

RESULTS AND DISCUSSIONS

The data in Figure 1 and Table 1 show that the grapevine growing season in 2025 was significantly warmer than the multiannual average. If the 90-year average temperature during the period March 1–September 30 was 18.5 °C, in 2025 it was 20.4 °C. Of the 6 months of the interval, only May had an average temperature lower than the 90-year average temperature (1.5 °C compared to 17 °C), otherwise all the other 5 months were much warmer. If the average temperature in April was almost 1 °C higher than the 90-year average temperature (12.3 °C compared to 11.5 °C), in June, July, August and September the differences were much greater, in some cases even by 3–4 °C. This shows that the summer of 2025 was excessively warm, as was the first month of autumn (September), which is also the last of the growing season.

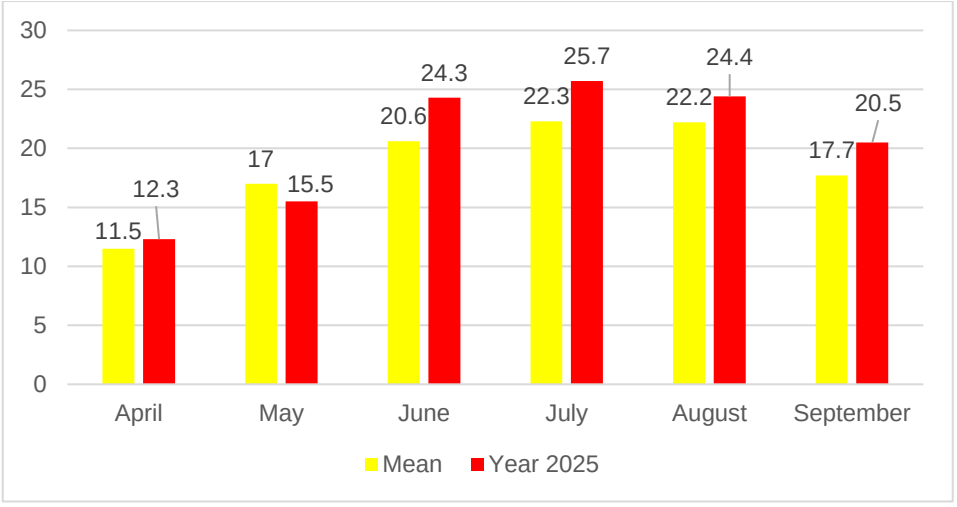

Figure 1. Average temperature in the grapevine growing season in 2025 compared to the 90-year average

So, even though the first two months of the grape growing season at Banu Mărăcine were slightly cooler than the 90-year average (13.9 °C vs. 14.2 °C), 2025 was much warmer due to the summer and early autumn months, which shows that grape growth and ripening in 2025 took place under conditions of excessive temperatures.

Table 2 and Figure 2 show the average daily temperatures for the entire grapevine growing season in 2025. Data analysis shows that the growing season started with 5 days with an average temperature above 10 °C, the warmest of which was April 5, with 13.6 °C, followed by a sharp cooling of the weather, a cold wave that lasted 4 days, the coldest being April 7 and 8, with average temperatures of 2.7 and 3.4 °C, with even negative temperatures (-1 °C) being recorded in the respective

mornings. The last negative temperature in 2025 was recorded on April 11, at 6:00 (-1 °C). After the cold wave passed, the weather returned to normal, gradually warming up and even a heat wave followed between April 20 and 26, with average daily temperatures of over 15 °C, the warmest being April 21 and 22, with average temperatures of 18.5 and 19.1 °C. In fact, on April 22, the 3:00 PM record shows the highest temperature of the month, 25 °C.

Table 1

Average temperature in the grapevine growing season in Banu Mărăcine viticultural area

	T min °C 90 years (1991-1990)	T max °C 90 years (1991-1990)	Average °C 90 years (1991-1990)	Temperature 2025 year °C
April	-5,5	31,8	11,5	12,3
May	-1,0	35,3	17,0	15,5
June	4,4	38,8	20,6	24,3
July	7,5	42,6	22,3	25,7
August	6,4	41,0	22,2	24,4
September	-3,0	40,1	17,7	20,5
Growing season	**1,5**	**38,2**	**18,5**	**20,4**

In May, after a warm start, especially May 4 and 5 being the warmest of the month, with 21.4 and 20.1 °C, the weather gradually but markedly cooled, especially May 10 (10.2 °C), May 12 and 13 (10.6 °C), the coldest of May. In fact, on May 13 at 3:00 (6 °C) and 6:00 (4 °C) the lowest temperatures of the month were recorded. Even though the weather continued to warm up, only one other day (May 23) with an average temperature of 20 °C was recorded in May, a day on which, at 6:00 p.m., the temperature record for May 2025 was recorded: 26 °C.

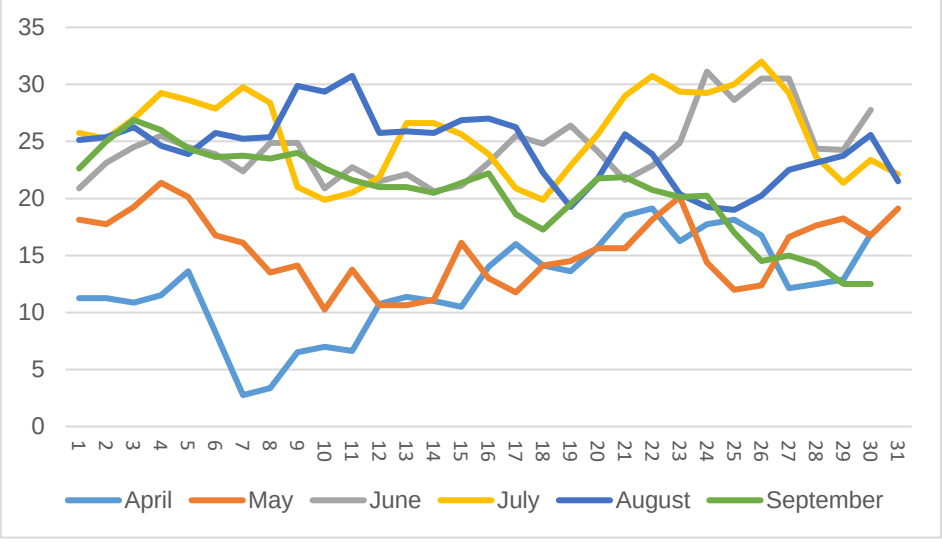

Figure 1. Average daily temperatures during the growing season, 2025

June was much warmer compared to the previous month and also to the 90-year average. If in the 90-year period the average temperature of June was 3.6 °C higher than the average temperature of May (20.6 °C compared to 17 °C), in 2025 the average temperature of June was almost 9 °C higher than the average temperature of May (24.2 °C compared to 15.4 °C). Compared to the 90-year period, June of 2025 was warmer by 3.7 °C.

At the beginning of June, 3 very hot days were recorded (June 3, 4 and 5), with average temperatures of 24.5 – 25.5 °C, on June 3, at 3:00 PM, the temperature of 30 °C was reached for the first time in 2025. The coldest day of the month was June 14, with an average temperature of 20.6 °C. The warmest day of the month was June 26 (average temperature of 30.5 °C), which was also the first day of the year when the temperature reached 37 °C, at 18:00.

Table 2

Average daily temperature in the grape growing season, 2025 year, Banu Mărăcine viticultural area

Days	April	May	June	July	August	September
1	11,2	18,1	20,9	25,7	25,1	22,6
2	11,2	17,7	23,1	25,2	25,4	25
3	10,9	19,2	24,5	27	26,2	26,9
4	11,5	21,4	25,5	29,2	24,6	26
5	13,6	20,1	24,5	28,6	23,9	24,4
6	8,2	16,7	23,9	27,9	25,7	23,6
7	2,7	16,1	22,4	29,7	25,2	23,7
8	3,4	13,5	24,9	28,4	25,4	23,5
9	6,5	14,1	24,9	21	29,9	24
10	7	10,2	20,9	19,9	29,4	22,6
11	6,6	13,7	22,7	20,5	30,7	21,6
12	10,9	10,6	21,5	21,9	25,7	21
13	11,4	10,6	22,1	26,6	25, 9	21
14	11	11,1	20,6	26,6	25,7	20,5
15	10,5	16,1	21,1	25,6	26,9	21,4
16	14	13	23,1	23,9	27	22,2
17	16	11,7	25,5	20,9	26,2	18,6
18	14,1	14,1	24,8	19,9	22,2	17,2
19	13,6	14,5	26,4	22,9	19,2	19,5
20	15,7	15,6	24,1	25,6	21,7	21,7
21	18,5	15,6	21,6	29	25,6	21,9
22	19,1	18,1	22,9	30,7	23,9	20,7
23	16,2	20,1	24,9	29,4	20,4	20,1
24	17,7	14,3	27,7	29,2	19,2	20,2
25	18,1	12	28,6	30	19	17
26	16,7	12,3	30,5	32	20,2	14,5
27	12,1	16,6	30,5	29,2	22,5	15
28	12,5	17,6	24,4	23,6	23,1	14,2
29	12,9	18,2	24,2	21,4	23,7	12,5
30	16,9	16,7	27,8	23,4	25,5	12,5
31		19,1		22,1	21,5	
Mean of the month	**12,3**	**15,4**	**24,2**	**25,7**	**24,4**	**20,5**

July was the warmest month of 2025, the only one with an average temperature above 25 °C, being 1.5 °C warmer than the previous month and 3.4 °C warmer than the 90–year average. In July, only 2 days (July 10 and 18) were recorded with an average temperature below 20 °C. Between July 21 and 27, a strong heat wave was recorded, with average daily temperatures of at least 29 °C, the hottest day being July 26, with an average temperature of 32 °C, the hottest in 2025. In fact, on this day, at 6:00 PM, the highest temperature of this year was recorded, 40 °C.

August was also extremely hot, with the average temperature being 2.2 °C higher than the 90–year average. In fact, there were only two days (August 19 and 25) with an average temperature below 20 °C, the only days in August when the maximum temperature did not reach 25 °C. The lowest temperature in August was 13 °C, on the 26th and 27th, at 6:00 AM. The warmest day of the month was August 11, the only day with an average temperature above 30 °C, which marked the end of a severe heat wave, being the day when the temperature record for the month was recorded, namely 37 °C. This is particularly important for the vine, because August marks the first ripe fruit phase and the beginning of grape ripening.

September was, like the previous months, particularly warm, almost 3 °C above the average temperature of the 90 years. In fact, this month there were 5 days with maximum temperatures of at least 30 °C, the warmest day being September 3 (26.9 °C), the only day of the month with an average temperature above 25 °C.

September 9, at 6:00 PM, was the last time in 2025 when a temperature of 30 °C was recorded.

September 30 was the only day in the month and the first in autumn when temperatures below 10 °C were recorded, namely 9 °C at 6:00 AM and 8 °C at 9:00 AM, this being the minimum of the month (the last time in 2025 when there were 8 °C was on May 18, at 9:00 AM, so 135 days ago).

CONCLUSIONS

The year 2025 was particularly warm, as evidenced by the average monthly temperatures in each month of the vine growing season, conventionally considered to be between March and September. The data recorded by the weather station located right in the vineyard highlight particularly high temperature values, especially starting with June, as April was close to the 90–year multiannual average, with a positive temperature difference of less than 1 °C, while May was even cooler by 1.5 °C. If in 2025, the temperature of 30 °C was recorded for the first time on June 3, at 3:00 PM, it was last recorded on September 9, at 6:00 PM, therefore at an interval of 97 days.

Regarding low temperatures, the last time the temperature of 10 °C was recorded was on May 25, and in autumn for the first time it was recorded on September 18, therefore at an interval of 126 days.

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