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LOCAL CLIMATIC REGIME: TEMPERATURE AND PRECIPITATION TRENDS IN THE CONTEXT OF GLOBAL WARMING

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Abstract

The climatological analysis for the period 2021-2025 highlights a clear warming trend in southeastern Romania compared with the multiannual averages for 1975-2022. The annual mean temperature ranged between 12.2°C and 13.7°C, exceeding in most years the climatological norm of 12.7°C, with more pronounced positive deviations during 2023-2025. The mean maximum temperatures reached 19.2°C in 2025, while extreme summer values exceeded 32.0°C, reflecting increasingly hot summers. The average minimum temperatures, between 6.9°C and 8.2°C, indicate warmer nights and milder winters, emphasizing thermal variability particularly in winter and spring months and an earlier onset of the warm season. The pluviometric regime shows significant variability, alternating between very wet and dry years, with uneven precipitation distribution concentrated in short, intense episodes. The 2021-2025 precipitation average is slightly above the multiannual mean; however, rising temperatures and altered rainfall patterns suggest an intensification of hydric stress. These climatic changes have a significant impact on fruit growing, influencing phenology, productivity, and water management, and requiring the adaptation of agricultural strategies and careful monitoring of the thermo-hydric regime in southeastern Romania.

Key words*: climate variability, regional adaptation, analysis.*

INTRODUCTION

Climate change represents one of the most significant challenges faced by Romanian agriculture, particularly the fruit-growing sector, which is highly dependent on local climatic conditions. Although several studies have documented climate change at national and regional scales, limited information is available regarding the recent thermo-hydric evolution at local fruit-growing stations in southeastern Romania. This study addresses this gap by providing a detailed assessment of temperature, precipitation, and aridity indicators recorded at Valu lui Traian during 2021-2025. In the southeastern region of the country, characterized by an excessively temperate-continental climate, the thermo-hydric regime has undergone significant changes in recent decades, with direct implications for fruit production (Bandoc & Pravalie, 2015; Croitoru et al., 2016). The increase in average annual temperatures, combined with the reduction in summer precipitation and the growing frequency of extreme weather events, leads to intensified thermal and water stress on fruit tree species (Pörtner et al., 2022; Li et al., 2023; Roussos, 2024). In Dobrogea, one of the most vulnerable regions in southeastern Romania, the frequency of pedological and atmospheric droughts has increased, causing physiological imbalances in trees, reduced vegetative growth, and a decline in fruit quality (Paltineanu et al., 2015; Barbulescu & Postolache, 2023). Severe water stress limits photosynthesis and transpiration, affecting the accumulation of dry matter and sugar content, which are essential for fruit quality (Ripoll et al., 2014; Mihaljević et al., 2021; Ma et al., 2022; Kang et al., 2024). These physiological disturbances are reflected in measurable agronomic outputs such as reduced fruit size, lower yield, altered sugar accumulation, and increased incidence of fruit defects. Moreover, high temperatures during the ripening period can cause sunburn on fruits, reducing their commercial value. On the other hand, changes in the thermal regime during winter have led to a decrease in the number of days with temperatures below 0°C, which can disrupt the dormancy period of fruit trees (Chitu et al., 2015; Croitoru et al., 2016; Paltineanu & Chitu, 2020). Premature vegetative growth, followed by late spring

frosts, negatively affects the flowering and fruiting phases, leading to significant yield losses (Rodrigo et al., 2006; Gu et al., 2008; Luedeling & Brown, 2011; Drepper et al., 2022; Cebulj et al., 2022; Chamberlain and Wolkovich, 2021; Žnidaršič et al., 2023). In this context, adapting fruit growing to new climatic conditions has become a strategic necessity. The selection of cultivars and rootstocks tolerant to thermal and water stress, the optimization of irrigation regimes, and the application of water-conserving technologies represent priority solutions (Pörtner et al., 2022). Additionally, monitoring the thermo-hydric regime and integrating climatic data into technological planning can help reduce risks and maintain the sustainability of orchards. The present study aims to analyze the impact of climate change on the thermo-hydric regime in the southeastern region of Romania. The objective of this study was to analyze recent changes in mean, maximum, and minimum air temperatures, the precipitation regime, the climatic water balance, and 'De Martonne' Aridity index during 2021-2025, using descriptive and correlation analyses, in order to evaluate the implications of climate change for fruit-growing systems in southeastern Romania.

MATERIALS AND METHODS

The study area selected for analyzing the impact of climate change on the thermo-hydric regime is located in southeastern Romania, in Valu lui Traian commune, Constanța County, with the following coordinates: 44°10′ N latitude, 28°40′ E longitude, and an altitude ranging from 40 to 80 m above sea level. This region is characterized by a temperate-continental steppe climate, marked by hot and dry summers and relatively mild winters, with average annual precipitation below 450 mm (Paltineanu et al., 2015; Bandoc & Pravalie, 2015). Fruit-growing has a long-standing tradition in the area, mainly represented by apricot, peach, apple, and sour cherry orchards species sensitive to thermal and hydric variations. The study area is representative of southeastern Romania due to its steppe climatic conditions, frequent drought occurrence and extensive fruit-growing activities, making it suitable for evaluating climate change impacts at the regional level. Apricot and peach are particularly sensitive to spring frosts and water deficits, while apple and sour cherry require sufficient winter chilling accumulation and adequate water availability during fruit development. For the analysis of the thermo-hydric regime during the 2021-2025 period, climate data series from the IMT 300 meteorological station, operated by the local unit, were used. The datasets included monthly and annual values of mean, maximum, and minimum temperatures and total precipitation. These values were compared with multiannual climatological averages calculated for the 1975-2022 period. Climatic data underwent routine quality control procedures, including consistency checks, detection of missing values, and comparison with neighboring stations when available. No major gaps were identified in the analyzed series. For the determination of the Climatic Water Balance (CWB), the formula proposed by Thornthwaite (1948) (CWB=P-ETP, where P- precipitation in mm and ETP-potential evapotranspiration in mm) was used, which expresses the difference between effective precipitation and potential evapotranspiration. Potential evapotranspiration was estimated using the Thornthwaite method based on monthly mean air temperature. Although this approach may underestimate evapotranspiration under semi-arid conditions, it remains widely used for comparative climatic assessments and long-term regional studies. Negative values of the CWB indicate periods of water deficit, which are relevant for assessing stress on fruit crops. The analysis was complemented by calculating the 'De Martonne' Aridity Index ($I_a = P / (T + 10)$, where P -precipitation, mm and T - mean air temperature, °C), used to classify the degree of climatic dryness of the region (Paltineanu et al., 2007).

The primary data were centralized and organized into monthly and annual tables using Microsoft Excel. To examine the relationships between climate variables, bivariate statistical analyses were performed using IBM SPSS Statistics software (version 26.0). Pearson correlation analysis was used to assess relationships among climatic variables. Statistical significance was evaluated at $p < 0.05$ and $p < 0.001$ levels. Due to the relatively short study period, no formal time-series trend analysis was applied.

RESULTS AND DISCUSSIONS

1. Air temperatures in the 2021-2025 period compared to the long-term averages for the reference interval 1975-2022

1.1. Analysis of the evolution of annual and monthly mean air temperatures

The mean annual air temperature varied between 12.2°C in 2021 and 13.7°C in 2023, values that exceed, in most cases, exceed the mean multiannual temperature of 12.7°C. This evolution indicates a progressive increase in the mean annual temperature, with a maximum positive deviation of approximately +1.0°C in the year 2023. In particular, the years 2023-2025 stand out for constant mean annual temperatures above the climatological average, confirming the warming trend of the analyzed region (Table 1). The observed warming is consistent with previous studies conducted in southeastern Romania and the Black Sea region, which reported increases in mean annual temperature of approximately 0.3-0.5°C per decade (Croitoru et al., 2016; Barbulescu & Postolache, 2023). The analyzed period covers only five years; therefore, the identified warming tendency should be interpreted as a recent climatic signal rather than a definitive long-term trend. At the monthly level, significant thermal variations are observed, especially in the transitional seasons (spring and autumn). January and February 2025 saw notable deviations from climatological values, with a mean temperature of 4.8°C in January (1.7°C above normal) and -0.8°C in February (below average 4.1°C). These thermal oscillations indicate an increase in climate variability during the cold period of the year. March, April, and May were generally warmer than the multi-year normal. In particular, the month of April 2024 recorded a value of 14.6°C, +4.0°C above the climatological average (10.6°C). This pattern is consistent with regional observations of an advancing warm season onset and an increasing frequency of early warming episodes. The months of June, July and August show relative thermal stability, with the values being close to or slightly higher than the multi-year averages. In July 2024, the mean air temperature reached 25.8°C, exceeding the norm by +1.9°C, and in June 2024, 23.5°C was recorded, compared with the multiannual air temperature of 21.2°C respectively. These positive deviations confirm the tendency of intensifying heat waves and extending hot periods. In the months of September, October, November, and December, the mean air temperature oscillated around the climatological values, but a slight decrease is noted in the months of October, November, and December 2024-2025, which can be attributed to changes in the regional atmospheric circulation and to an increase in the frequency of cold air episodes (Table 1). The comparative analysis of thermal data for the period 2021-2025 indicates an increase in the average annual temperature compared with the multiannual average 1975-2022, with constant positive deviations in most years. Seasonal analysis showed warmer springs and summers compared with the multiannual averages. These results support the hypothesis of local climate warming, consistent with trends observed on a global scale, and underline the need for continuous monitoring of climate parameters to identify and quantify thermal regime in the context of current climate change.

Table 1. Annual and monthly mean air temperatures for the 2021-2025 period, compared with the long-term mean temperatures for the reference interval 1975-2022

Month	Mean air temperature (°C)					Multiannual mean air temperature 1975-2022 (°C)
	2021	2022	2023	2024	2025	
January	3.4	2.0	5.6	1.9	4.8	1.7
February	3.2	4.5	3.3	7.7	-0.8	4.1
March	4.7	2.7	7.2	7.7	9.2	5.6
April	9.2	11.4	9.9	14.6	9.8	10.6
May	16.2	16.4	15.5	15.0	14.9	16.4
June	20.0	21.1	20.7	23.5	22.1	21.2
July	24.2	23.7	24.5	25.8	24.8	23.9
August	23.5	24.5	24.9	24.0	22.8	24.0
September	17.5	18.6	21.3	19.3	18.9	19.1
Octomber	11.1	13.6	16.6	12.5	12.0	13.3
November	8.7	9.4	9.3	5.6	10.9	8.2
December	4.1	4.5	5.4	4.3	3.7	4.3
Mean	**12.2**	**12.7**	**13.7**	**13.5**	**12.8**	**12.7**

1.2. Analysis of the evolution of annual and monthly mean maximum air temperatures

The annual average of the mean maximum air temperature for the interval 2021-2025 varied between 18.0°C and 19.6°C, values higher than the multiannual average (18.7°C) in most of the analyzed years. The year 2023 recorded the highest annual average (19.6°C), suggesting a warmer thermal character (Table 2). Overall,

the analyzed period confirms the climate warming trend, manifested by the increase in the frequency and intensity of high thermal values. The regime of monthly mean maximum temperatures shows a progressive increase from January to July, with minimum values in January and February and maximum values in July and August. The summer months consistently exceeded 30°C, indicating a pronounced warm character. The mean number of summer days with absolute maximum temperatures between 30°C and 40°C was 59 days in 2021-2025 period. Increasing maximum temperatures may accelerate fruit maturation, increase evapotranspiration demand, and enhance the risk of sunburn damage, requiring improved irrigation scheduling and canopy management. The transition months, April-May and September-October, show significant interannual variations, reflecting seasonal instability. Compared to the multiannual mean (1975-2022), frequent positive deviations are observed, especially in the summer and early autumn months.

Table 2. Annual and monthly mean maximum air temperatures for the 2021-2025 period, compared with the long-term mean maximum temperatures for the reference interval 1975-2022

Month	Mean maximum air temperature (^{0}C)					Multiannual mean maximum air temperature 1975-2022 (^{O}C)
	2021	2022	2023	2024	2025	
January	7.2	6.3	9.6	6.7	10.5	6.1
February	8.1	10.3	8.1	12.7	3.4	9.4
March	10.1	7,8	12.6	12.6	15.5	11.3
April	15.1	18.2	15.2	21.2	16.2	17.3
May	22.9	24.2	21.9	20.9	21.3	23.2
June	26.4	28.0	27.9	30.6	29.6	27.9
July	31.5	31.3	31.8	32.8	31.9	31.2
August	31.4	32.1	31.4	31.1	30.5	31.3
September	24.9	26.0	27.6	25.6	25.5	26.1
Octomber	16.1	21.3	24.3	19.7	16.4	19.3
November	14.0	14.6	14.2	11.4	15.2	13.0
December	7.9	9.3	10.2	7.5	14.9	8.2
Mean	**18.0**	**19.1**	**19.6**	**19.4**	**19.2**	**18.7**

1.3. Analysis of the evolution of annual and monthly mean minimum air temperatures

The annual average of the mean minimum temperature for the analyzed interval varied between 6.7°C (2025) and 8.2°C (2023), values close to or slightly higher than the multiannual mean minimum temperature of 7.2°C. The increase in minimum temperatures agrees with regional climate projections for southeastern Europe. Warmer winters may reduce chilling accumulation, affecting dormancy release and flowering synchronization in fruit trees. The years 2023 and 2024 are notable for higher mean minimum temperatures, compared to the rest of the analyzed period. The monthly mean minimum temperature shows negative values in the winter months, especially in January (-2.4°C, -1.8°C) and February (-4.9°C, -1.1°C), followed by a progressive increase in the warm season. In the months of July and August, the highest mean minimum temperature values are recorded, 16.5°C and 16.9°C respectively, indicating persistent warm nights (Table 3). Future analyzes will include frost frequency and number of frost days, which are critical indicators for risk assessment in fruit production.

Table 3. Annual and monthly mean minimum air temperatures for the 2021-2025 period, compared with the long-term mean minimum temperatures for the reference interval 1975-2022

Month	Mean minimum air temperature (^{0}C)					Multiannual mean minimum air temperature 1975-2022 (^{O}C)
	2021	2022	2023	2024	2025	
January	0.0	-1.8	2.1	-2.4	0.4	-2.2
February	-1.1	-0.3	-0.8	3.6	-4.9	-0.7
March	-0.1	-2.2	2.3	3.3	3.7	0.4
April	4.2	5.9	5.0	8.3	3.9	4.5
May	10.2	8.9	9.3	9.4	9.0	10.0
June	15.1	14.6	13.4	16.0	13.9	15.3
July	17.2	15.8	17.5	18.8	17.2	16.5
August	15.9	17.9	18.5	17.5	14.6	16.9
September	10.7	12.1	15.6	13.9	13.0	12.4
Octomber	6.9	6.8	9.6	7.0	8.7	8.0
November	4.5	4.7	4.4	0.8	7.6	4.0
December	0.8	0.7	1.5	1.4	-7.0	0.9
Mean	**7.0**	**6.9**	**8.2**	**8.1**	**6.7**	**7.2**

Considering the general trend of increasing mean air temperatures and the intensification of seasonal variability observed in the 2021-2025 period, the simultaneous analysis of the pluviometric regime is necessary to understand the current climate trends and their impact on fruit growing.

2. Analysis of the pluviometric regime in the 2021-2025 period compared with the long-term values for the reference interval 1975-2022

The pluviometric regime is one of the main indicators of local climate characteristics and an essential element in the assessment of the water balance. The present analysis follows the

annual and monthly evolution of precipitation for the 2021-2025 period, compared to the multiannual pluviometric regime (1975-2022), with the aim of highlighting deviation trends from the climatic norm and possible signs of aridity. The pronounced variability of precipitation observed during the study period reflects the increasing climatic instability characteristic of southeastern Romania. Although annual precipitation totals occasionally exceeded the multiannual average, the rainfall distribution became increasingly irregular, with prolonged dry intervals interrupted by short episodes of intense precipitation. The annual values of the pluviometric regime varied significantly in the analyzed interval, from 816.0 mm (2021), with 345.2 mm above the multiannual value indicating favorable water conditions, to 355.0 mm (2022) representing only 75% of the multiannual value, which suggests a pronounced drought (Table 4). The annual average for the 2021-2025 is 554.6 mm, slightly above the multiannual value (470.8 mm), but with large interannual fluctuations, a sign of increased climatic instability. The monthly analysis reveals clear seasonal variations between the cold and warm periods of the year. The period January - March experienced pronounced oscillations from one year to another. If, in 2021 there were abundant precipitation episodes, 86 mm in January, two and a half times more than the multiannual value (33.2 mm) and 65.8 mm in March, twice more than the multiannual value (32.2 mm), starting from the year 2022, for the same interval, precipitation decreased considerably, reaching up to 1.2 mm in February 2024 indicating a deficient regime. This highlights a sudden reduction in water supply during the winter months and the beginning of spring. The spring months show large variations, from 11.0 mm in May 2023 to 105.8 mm in April 2023. In general, 2021 (April and May), 2023 (April), 2024 (April) and 2025 (May) were characterized by high amounts of precipitation above the multiannual values (31.9 mm in April and 42.1 mm in May), which suggests a reactivation of the wet regime in spring. June and August are the most variable months, with precipitation above the multiannual values in June 2021, 124.2 mm respectively, in July 2022 with 68.4 mm and in August 2024 with 155.2 mm. The lowest amount of precipitation was recorded in June 2025, 1.2 mm respectively, followed by August and July 2023 with 7.2 mm and 11.0 mm, respectively, indicating an accentuated dry period in the height of summer, associated with high temperatures and increased evapotranspiration. The months of September and October mark an improvement in the rainfall regime (101.8 mm in September 2024, 138.6 mm in October 2021) with values above the multiannual average (47.5 mm in September and 48.6 mm in October), with the exception of October of the years 2022 (6.8 mm) and 2023 (21.0 mm) when the pluviometric regime was below the multiannual value. This monthly analysis confirms a seasonal reorientation of precipitation, with episodes of heavy rain in autumn. The end-of-year months (November and December) show large variations, with a pronounced maximum in November 2023 (159.2 mm), almost six times above the multiannual value (27.9 mm) indicating an extreme rainfall event, and a minimum in December 2022 (16.0 mm), almost three times below the multiannual average (44.0 mm) (Table 4). Extreme precipitation events were likely associated with Mediterranean cyclones and atmospheric blocking patterns, while severe drought periods were linked to persistent anticyclonic conditions and enhanced summer evapotranspiration.

Table 4. Annual and monthly precipitations for the 2021-2025 period, compared with the long-term values of precipitation for the reference interval 1975-2022

Month	Pluviometric regime (mm)					Multianual pluviometric regime 1975-2022 (mm)
	2021	2022	2023	2024	2025	
January	86.0	13.6	32.2	11.2	17.6	33.2
February	18.8	26.4	7.6	1.2	3.6	46.2
March	65.8	10.4	20.8	30.8	5.2	32.2
April	66.8	30.8	105.8	84.8	20.8	31.9
May	87.8	22.8	11.0	37.6	57.2	42.1
June	124.2	47.6	22.8	18.8	1.2	63.6
July	30.4	68.4	11.0	19.6	39.8	42.0
August	17.6	10.4	7.2	155.2	18.2	11.6
September	62.6	76.0	68.4	101.8	53.2	47.5
Octomber	138.6	6.8	21.0	81.0	100.8	48.6
November	40.8	25.8	159.2	56.4	56.4	27.9
December	76.6	16.0	44.6	97.2	20.6	44.0
Sum	**816.0**	**355.0**	**511.6**	**695.6**	**394.6**	**470.8**

3. Analysis of the climatic water balance for the 2021-2025 Period

The climatic water balance (CWB) is an indicator that provides a comprehensive view of the soil moisture regime and implicitly of the

availability of water resources for vegetation. During the 2021-2025 period, the CWB exhibits negative annual values in all analyzed years, ranging from -48.6 mm in 2021 to -566.8 mm in 2022. The multiannual mean for this period is -370.6 mm, indicating a deficient water regime. The monthly evolution of the CWB reflects a typical seasonal distribution for areas with a continental climate. The November-January interval is characterized by moderate water surpluses due to reduced evapotranspiration. Positive values in January (+15.4 mm), November (+45.5 mm), and December (+37.4 mm) indicate a consistent replenishment of soil water reserves. Spring (March-May) marks the transition to a water deficit, with mean values ranging from -21 mm to -77 mm, driven by rising temperatures and intensified evapotranspiration. The June-August interval represents the most critical period, characterized by extreme water deficits reaching -131.1 mm in July. These values indicate severe drought conditions, which strongly affect fruit crops. Severe summer deficits highlight the increasing importance of irrigation systems and water-saving technologies for maintaining orchard productivity. September and October bring a partial improvement in water availability, with values close to equilibrium (-20 mm in September and +23.8 mm in October), driven by reduced evapotranspiration and the resumption of precipitation (Table 5). The five-year CWB analysis highlights a progressive aridification. Nevertheless, because the analyzed period is relatively short, the apparent tendency toward increasing aridity should be interpreted cautiously and verified using longer climatic records.

Table 5. Annual and monthly values of the climatic water balance for the 2021-2025 period

Month	CWB (mm)					Mean (2021-2025)
	2021	2022	2023	2024	2025	
January	73.6	-5.0	13.6	-7.4	2.1	15.4
February	-3.6	-4.4	-23.2	-39.4	-18.8	-17.9
March	16.2	-39.2	-31.9	-18.8	-56.8	-26.1
April	-5.2	-62.2	36.8	-14.2	-60.2	-21.0
May	-36.2	-107.4	-106.8	-77.1	-57.5	-77.0
June	-1.8	-81.4	-118.2	-146.2	-157.8	-101.1
July	-127.7	-95.9	-150.2	-150.9	-130.7	-131.1
August	-121.9	-126.0	-135.4	18.2	-127.5	-98.5
September	-27.4	-14.0	-36.6	14.8	-36.8	-20.0
Octomber	101.4	-39.7	-44.1	37.6	63.6	23.8
November	19.8	4.8	129.2	38.4	35.4	45.5
December	64.2	3.6	26.0	84.8	8.2	37.4
Sum	**-48.6**	**-566.8**	**-440.8**	**-260.2**	**-536.8**	**-370.6**

4. Analysis of the 'De Martonne' Aridity Index for the 2021-2025 Period

The analysis of the 'De Martonne' aridity index for the period 2021-2025 indicates significant monthly and interannual variations. Monthly mean values range between 0.9 (February) and 3.6 (November) (Table 6). The months of July (I_a=1.0) and August (I_a=1.2) show extreme drought, while October 2021 (I_a=6.6), November 2023 (I_a =8.2), and December 2021 (I_a=6.8) indicate relatively higher humidity in late autumn and winter. According to the classical De Martonne classification, values below 10 characterize arid climatic conditions, values between 10 and 20 indicate semi-arid environments, while higher values correspond to increasingly humid climates. The predominance of low index values throughout the analyzed period confirms the persistence of arid conditions in the study area.

Table 6. 'De Martonne' Aridity Index for the 2021-2025 period

Month	De Martonne Aridity Index					Mean (2021-2025)
	2021	2022	2023	2024	2025	
January	6.4	1.1	2.1	0.9	1.2	2.3
February	1.4	1.8	0.6	0.1	0.4	0.9
March	4.5	0.8	1.2	1.7	0.3	1.7
April	3.5	1.4	5.3	3.4	1.1	2.9
May	3.4	0.9	0.4	1.5	2.3	1.7
June	4.1	1.5	0.7	0.6	0.0	1.4
July	0.9	2.0	0.3	0.5	1.1	1.0
August	0.5	0.3	0.2	4.6	0.6	1.2
September	2.3	2.7	2.2	3.5	1.8	2.5
Octomber	6.6	0.3	0.8	3.6	4.6	3.2
November	2.2	1.3	8.2	3.6	2.7	3.6
December	5.4	1.1	2.9	6.8	1.5	3.5
Meen	**3.4**	**1.3**	**2.1**	**2.6**	**1.5**	**2.2**

Spring presents moderate values, with a peak in April 2022 (I_a=5.3). The mean annual index I_a=2.2 confirms the predominance of arid conditions, with short periods of more pronounced moisture (Table 6). The consistency between the De Martonne Aridity Index and the Climatic Water Balance demonstrates the reliability of both indicators in characterizing moisture availability and drought severity within fruit-growing ecosystems.

5. Statistical analysis of relationships between climatic parameters

- Correlation P vs. CWB (Precipitation vs. Climatic Water Balance). The relationship between precipitation and the Climatic Water Balance (CWB) is positive and statistically

significant ($p < 0.001$). However, the moderate value of the R^2 coefficient (0.3935) suggests that precipitation explains only approximately 40% of the water balance (Table 7, Figure 1). The remaining 60% is massively influenced by potential evapotranspiration. This indicates a climate where, even in rainy months, water loss through evaporation (caused by high temperatures) can maintain a water balance deficit. The relatively short observation period may limit the robustness of the identified statistical relationships.

- Correlation T_{med} vs. CWB (Mean Temperature vs. Climatic Water Balance). There is a distinct negative correlation between mean temperature and the climatic water balance ($r = -0.677$). As the temperature rises, the CWB decreases, frequently entering the zone of negative values (deficit). This inverse relationship confirms the arid character of the summers during the 2021-2025 interval, where high temperatures accelerate evapotranspiration at a rate faster than the pluviometric input can compensate (Table 7, Figure 2).

- Correlation I_a vs. Tmean ('De Martonne' Aridity Index vs. Mean Temperature). This is the only correlation that does not reach the standard threshold of statistical significance ($p = 0.068 > 0.05$). The weak negative relationship shows that the aridity index is not dictated exclusively by temperature. Although high temperatures tend to lower the index (towards aridity), the influence of precipitation is much more determinant in the calculation of this index than that of temperature (Table 7).

- Correlation I_a vs. P ('De Martonne' Aridity Index vs. Precipitation). The very strong correlation ($r = 0.906$) confirms that the pluviometric regime is the main factor controlling aridity in the studied area. Variations in the 'De Martonne' Aridity Index faithfully follow the precipitation curve ($R^2 = 0.820$), demonstrating that any decrease in precipitation quantity leads directly and immediately to an accentuation of the degree of aridity, without other factors being able to significantly temper this effect (Table 7, Figure 3).

- Correlation I_a vs. CWB ('De Martonne' Aridity Index vs. Climatic Water Balance). The close relationship between these two indicators validates the consistency of the climatic data. Since both indices measure, in different forms, the availability of water in the ecosystem, the strong positive correlation ($r = 0.792$) shows that periods classified as "arid" or "semi-arid" according to 'De Martonne' correspond faithfully to periods with a major soil water deficit (negative CWB), confirming the agricultural vulnerability of the area during drought intervals (Table 7, Figure 4).

Table 7. Pearson correlation (r), determination coefficients (R-squared), and significance levels (p-value) for the analyzed climatic parameters

Variable Pair	Pearson Correlation (r)	R-squared (R^2)	Significance (p-value)
P vs. CWB (Precipitation vs. Climatic Water Balance)	0.627	0.3935	< 0.001
Tmed vs. CWB (Mean Temperature vs. Climatic Water Balance)	-0.677	0.4583	< 0.001
I_a vs. Tmed ('De Martonne' Aridity Index vs. Mean Air Temperature)	-0.237	0.056	>0.05
I_a vs. P ('De Martonne' Aridity Index vs. Precipitation)	0.906	0.8201	< 0.001
I_a vs. CWB ('De Martonne' Aridity Index vs. Climatic Water Balance)	0.792	0.6271	< 0.001

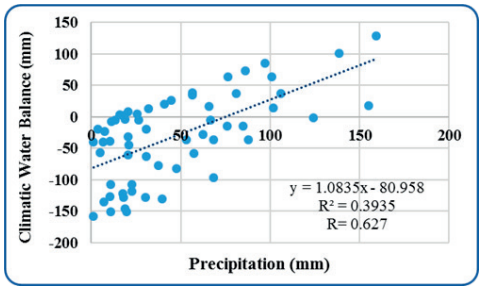

Figure 1. Correlation between the Precipitation (P) and the Climatic Water Balance (CWB) during the 2021-2025

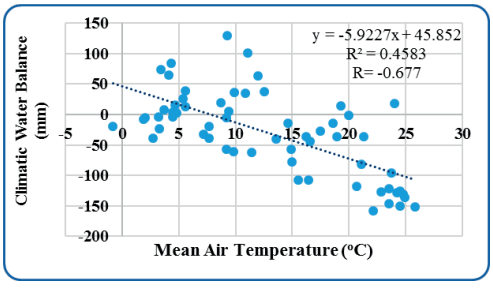

Figure 2. Correlation between the Mean Air Temperature (Tmed) and the Climatic Water Balance (CWB) during the 2021-2025

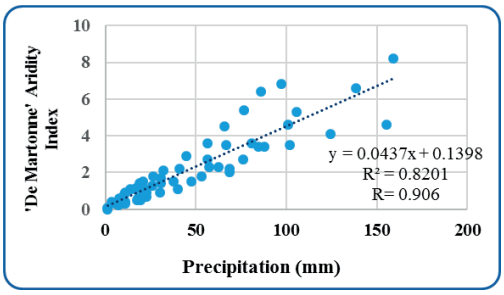

Figure 3. Correlation between the Precipitation (P) and the 'De Martonne' Aridity Index (I_a) during the 2021-2025

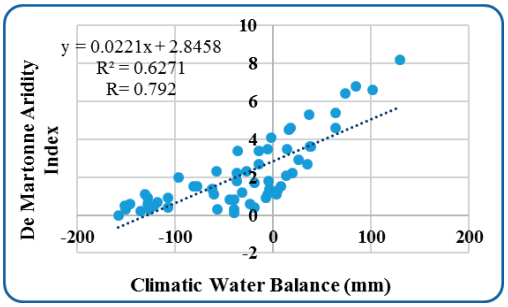

Figure 4. Correlation between the Climatic Water Balance (CWB) and the 'De Martonne' Aridity Index (I_a)

The identified relationships can support drought risk assessment and the optimization of irrigation management in fruit-growing systems.

CONCLUSIONS

Mean air temperatures during 2021-2025 generally exceeded the long-term average, confirming a warming trend and an increased frequency of high-temperature events. The adoption of heat-tolerant cultivars and improved orchard management practices is recommended to reduce thermal stress.

Annual precipitation totals were generally close to normal, but their uneven seasonal distribution, characterized by summer deficits and intense rainfall episodes, indicated increased variability of the precipitation regime. Continuous monitoring of precipitation, together with the implementation of efficient soil moisture conservation measures, is recommended to mitigate the effects of rainfall irregularity.

Predominantly negative Climatic Water Balance values reflected persistent water deficits and increasing pressure on water resources. Optimized irrigation scheduling and the use of water-saving technologies are essential to maintain orchard productivity.

The 'De Martonne' Index indicated predominantly arid conditions, especially during summer, highlighting the combined effects of reduced precipitation and elevated temperatures. Adaptation strategies aimed at improving drought resilience and water-use efficiency should be prioritized (e.g., drought-tolerant cultivars, optimized irrigation scheduling, mulching, and soil moisture conservation techniques).

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