Scientific Papers. Series B, Horticulture. Vol. LXVIII, No. 2, 2024
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

WHAT IS THE DIFFERENCE BETWEEN THE INTERNATIONAL/ NATIONAL AND LOCAL METEO STATIONS FOR ONE SPECIFIC ORCHARD? ALMOST 100 YEARS OF RECORDS DATABASE ANALYSIS

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Abstract

Temperature is one of the most controversial parameters studied in fruit-growing technologies, considering the direct influence on each growing stage of the plant and not only. Climate change has led to strategies and specific measures for managing extreme events in recent years. More international meteo stations have continuous data specific to a larger or delimited area. However, modern technologies require more accurate records that are as close as possible to the crop, giving a trend to have in each specific point local meteo stations. This study compares the parameters recorded by the international/national and local meteo stations for a specific orchard in Bucharest, Romania. Dynamics of chilling hours, chilling portions, and Growing degree hours are also presented.

Key words: *phenology, temperature, GDH, CP, CH.*

INTRODUCTION

Temperature is one of the most controversial parameters studied in fruit-growing technologies, considering the direct influence on each growing stage of the plant and not only. Climate change has led to strategies and specific measures for managing extreme events (Benmoussa et al., 2020; Fernandez et al., 2021; 2023). More international meteo stations have continuous data specific to a larger or delimited area (Ecad.Eu, 2024; Luedeling et al., 2009). However, modern technologies require more accurate records that are as close as possible to the crop, giving a trend to have in each specific point local meteo stations. Modeling the correlation between tree-growing stages (Meier, 2018) and climate factors, especially temperatures, have been studied since the early XX century (Luedeling, 2012). Still, more accurate models have been elaborated and implemented in the last years due to technological and artificial intelligence advancements. Most of them focused on the accumulation of chilling hours by the trees, more of the traditional fruit-growing areas being threatened in the following years to change the cultivar's assortment with those with low chilling requirements (South Spain, Mediterranean area, etc.) (Drogoudi et al., 2023). Most of the algorithms include different analyses of chilling hours accumulation, widely used being the chilling hours (CH) model, the Dynamic model, and the heat accumulation Growing Degree Hours (GDH) model (Al Suwaid et al., 2023).

Worldwide, there is a network of meteo stations where historical data are available online and can be used in models (Ecad.Eu, 2024, R linked databases). Local stations are required for more precise analysis, but there are many cases when they are unavailable, or the recordings have gaps.

This study compared the parameter temperature recorded by international/national and local meteo stations for a specific orchard in Bucharest, Romania. It also presents the dynamics of chilling hours, chilling portions, and Growing degree hours for the studied periods.

MATERIALS AND METHODS

The international/national Bucharest Băneasa meteo station data for 1929-2023 were downloaded and analyzed (Ecad.Eu, 2024). Three local stations, coded Pessle, Enten, and Pinova, were compared for temperature data for the last four years.

Bucharest Băneasa, placed at the extremity of the city, at 4.3 km from the University campus, recorded only daily values for minimum, maximum, and average temperatures. Filling day gaps and transforming daily hourly data have been done with the chillR v. 0.75 package from R software. In the Experimental fields of the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Pinova meteo station is situated in a region surrounded very closely by buildings, while Enten and Pessle stations, at 1 km distance, in a plainer field. All of them are in the Agronomie - Herastrau University campus, in the North-West part of Bucharest city (44º28'12", 26º03'51", 86 m altitude).

Daily and hourly temperatures were used for the local stations, and the chillR v. 0.75 package from R software was used to fill in gaps in days or hours.

Chilling Hours (CH), Chilling Portions (CP), and Growing Degree Hours (GDH) were determined using the same R package functions based on the hourly temperatures for all stations. Statistical analysis was performed with the R program (with RStudio 2024.04.2+764), and ANOVA with Tuckey posthoc tests were used for p<0.5 significance.

RESULTS AND DISCUSSIONS

Trends and dynamics in temperature at Bucharest-Băneasa international/national station

Annual mean temperature dynamics for maximum (Tmax), minimum (Tmin), and average (Tavg) values were compared statistically from 1929 to 2023 (Figure 1).

Annual average temperature (Tavg) fluctuated, ascending from 10 to 13ºC in the last years. Maximum yearly temperature (Tmax) ranged between 14-18ºC and ascended from 16 to 21ºC in the previous twenty years. Annual minimum temperature (Tmin) ranged between 3 to 7ºC, with a similar ascending trend in the last years.

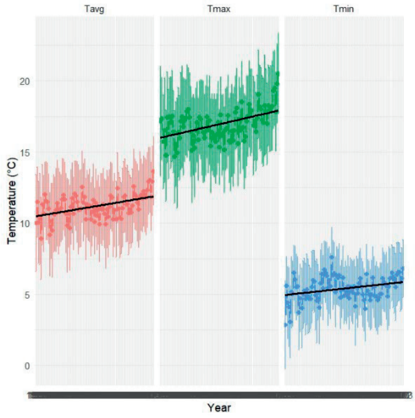

Figure 1. Average, maximum, and minimum temperatures in the 1929-2023 period

The analyzed data show that Bucharest's average temperature has increased over the last 23 years, with four years having values between 10-11ºC, 11 years with annual temperatures between 11 and 12ºC, six years between 12 and 13ºC, and the last 2 years between 13 and 14ºC. Compared to the previous periods, annual temperatures of 11-12ºC were present in all intervals, 12-13ºC one year from twenty, and none for 13-14ºC (Figure 2).

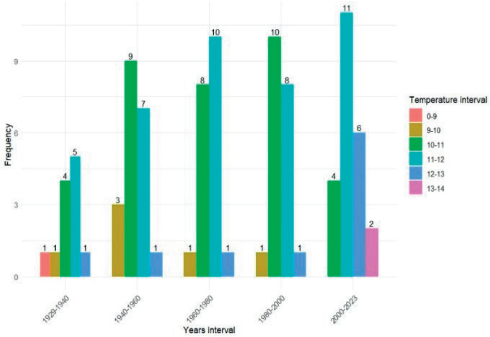

Figure 2. Frequencies of occurrences of average annual Tavg by temperature intervals and years

For monthly average temperature distributions, July and August had similar values for Tavg, Tmax, and Tmin. April and October also presented similar values. Multiannual monthly values are presented in Figure 3.

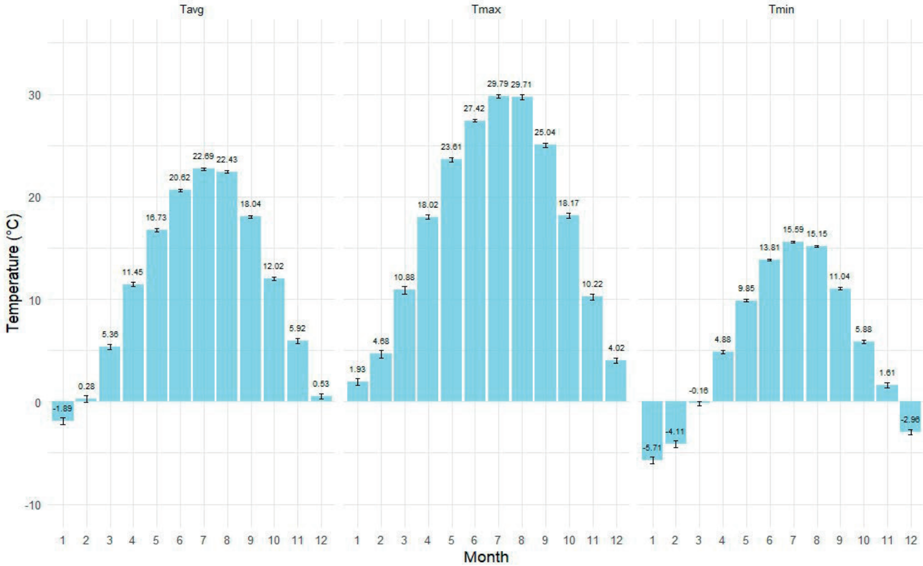

Figure 3. Monthly mean temperatures

Analyzing monthly temperature dynamics (Figure 4) from 1929 to 2023, it can be observed that some months, such as April, May, June, July, August, September, and October, presented a constant trend. However, January, February, and March had a distinct ascending trend, showing higher temperatures. In the last period, November and December had a slightly ascending trend, presenting more warmed months. The minimum (Tmin) and maximum (Tmax) followed the same pattern (Figure 5).

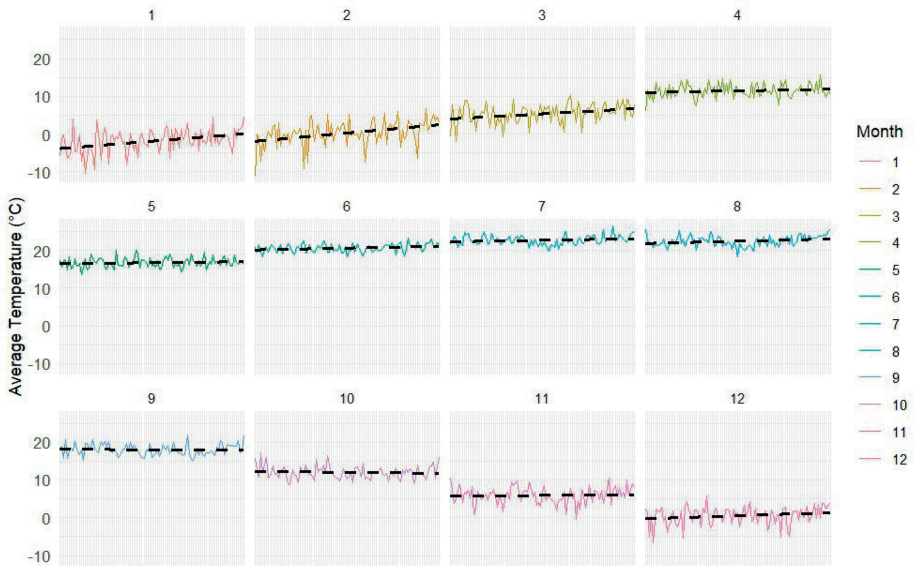

Figure 4. Monthly average temperature trends by year (1929-2023)

Figure 5. Evolution of extreme temperatures each month and year

An indicator directly influencing tree phenology is the days under 0ºC, between 0ºC and 7.2ºC, and above 7.2ºC (Figure 6). At the beginning of the interval, it can be observed that there were more than 50 days under 0ºC per year as usual; in the last 23 years, under 50 days were usual, and in the previous five years, 11-28 days were recorded under 0ºC. The interval of 0-7.2ºC of temperatures directly influences the dormancy break in trees, being relatively in a constant trend in the period. More than 7.2°C days were recorded in the last part of the period.

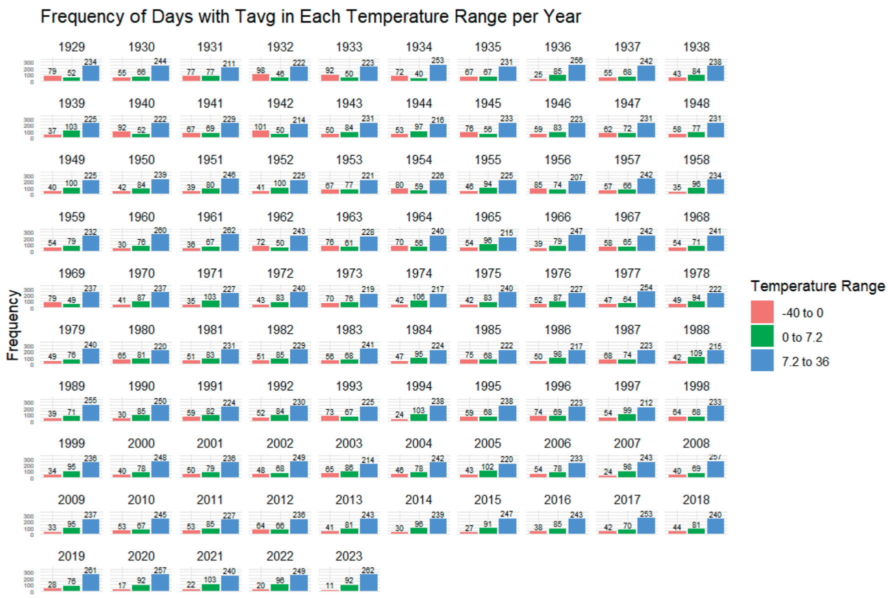

Figure 6. Frequency of Days with Tavg in each temperature range per year.

Temperature comparison between Bucharest-Băneasa international/national and local stations

When comparing annual temperatures between stations in the last four years, Tmax values were similar. Still, Tmin and Tavg presented differences between Băneasa and local stations (Figure 7), confirming the place's protective nature inside Bucharest. Annual monthly temperature followed the same pattern.

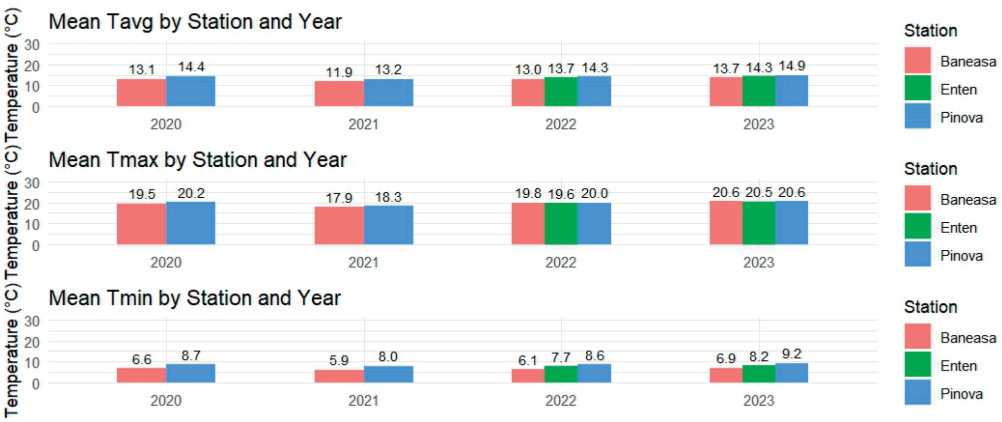

Figure 7. Annual Tavg comparison between stations

Hourly intervals in the day when minimum and maximum temperatures appear

Literature and most of the models take into consideration down intervals (4-6 am) for minimum temperature occurrence and 2 pm for maximum temperature of the day. In the analyzed data for the local stations, it was observed that Enten station presented the minimum in the day at 11 pm, 3 and 2 am, and maximum to 1 pm. Pessle station had a minimum at 5 and 6 am and a maximum at 3 pm. Pinova station recorded the minimum at 5 am, 4, and 6 am and the maximum at 3 and 2 pm (Figures 8-9).

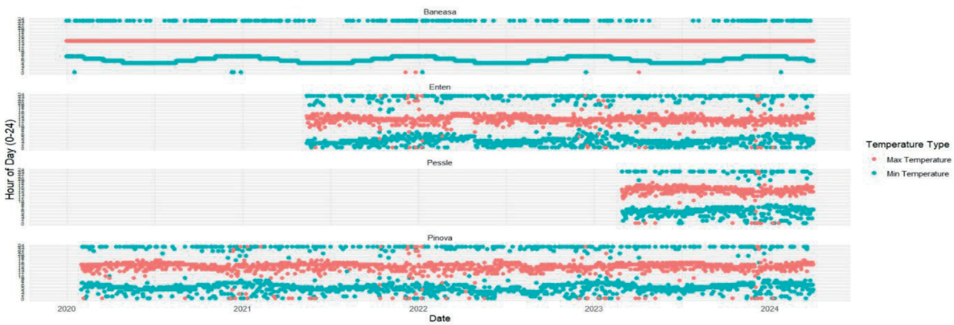

Figure 8. Times of minimum and maximum temperatures by stations

Figure 9. Times of minimum and maximum temperature frequency by stations

Chilling and Heat accumulation comparison
Analyzing the entire interval at the Băneasa station, the accumulation of Chilling Portions (CP) and Chilling Hours (CH) was within a range that assured sufficient chilling for the local temperate fruit species (Figures 10 and 11) correlated to (Fernandez et al., 2023). The cumulative growing degree hours (GDH) are presented in dynamics in Figure 12.

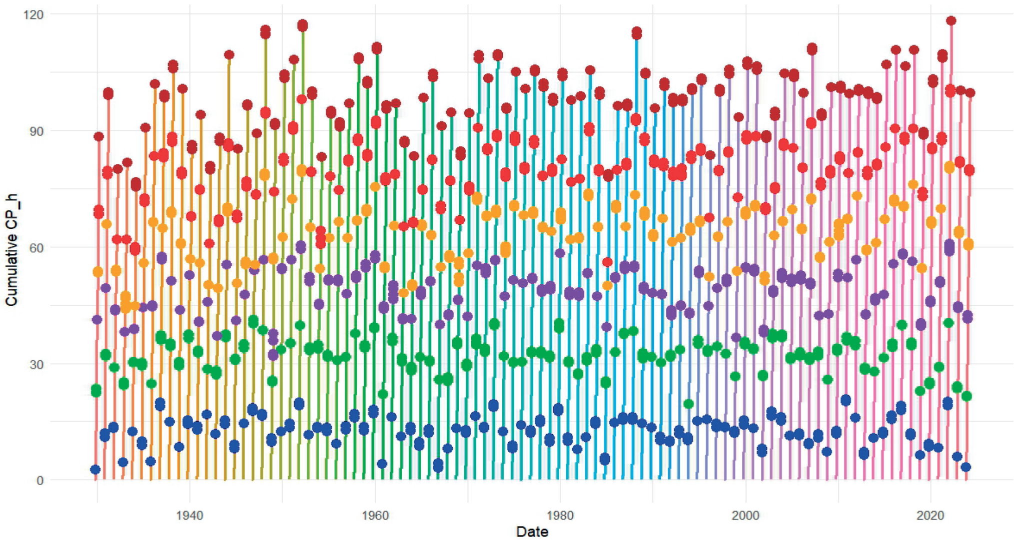

Figure 10. Cumulative CP (October-March) across years 1929-2024

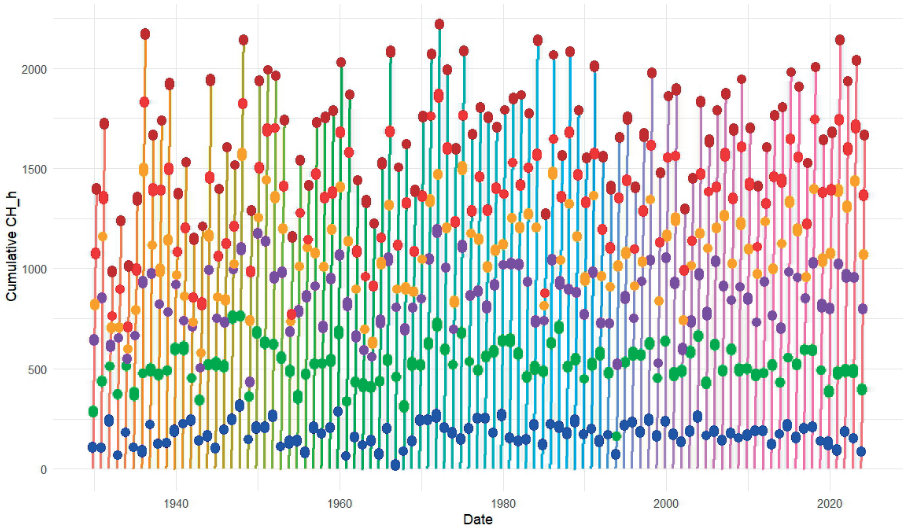

Figure 11. Cumulative CH (October-March) across years 1929-2024

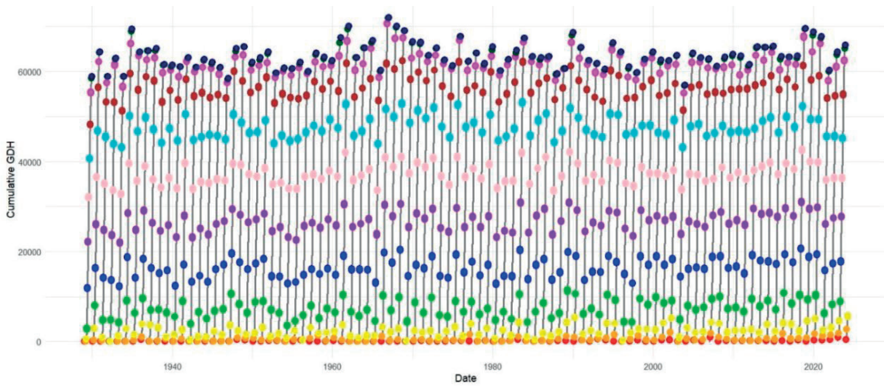

Figure 12. Cumulative GDH (January - December) across years 1929-2023

When comparing CP and CH between stations, all stations had similar values in the last four years (Figures 13 and 14).

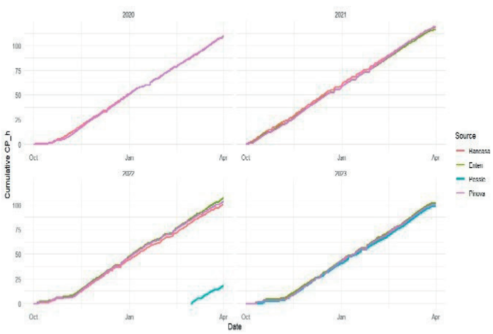

Figure 13. Cumulative CP (October-March) 2020-2023

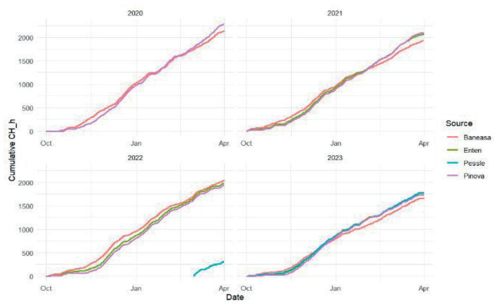

Figure 14. Cumulative CH (October-March) 2020-2023

For heat accumulation, expressed with the GDH parameter, there were differences between local stations and Băneasa stations, with higher values at the first ones (Figure 15).

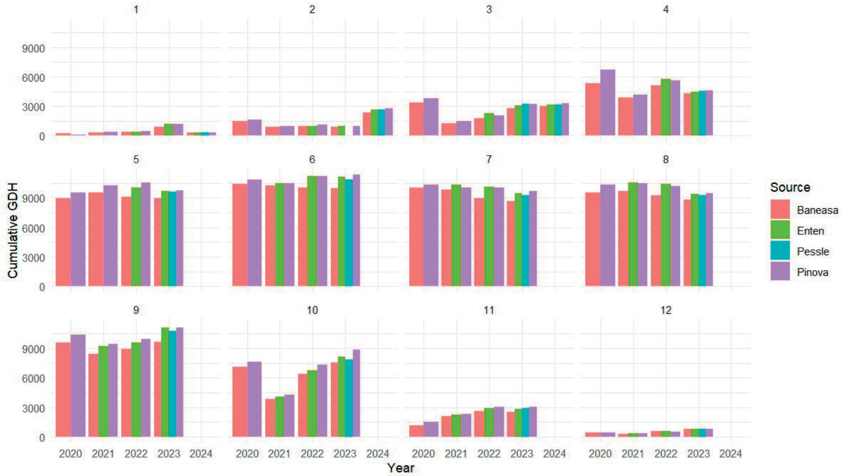

Figure 15. Comparing monthly cumulative GDH by year across stations

The number of tropical nights (with temperatures below 20 ºC, between 8 pm and 6 am) also differed between stations (Figure 16).

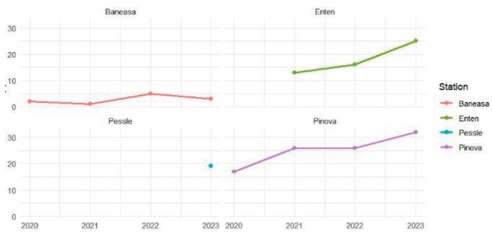

Figure 16. Tropical nights comparison between stations.

CONCLUSIONS

Climate change, including horticulture, has become a top priority on almost every agenda. The present study analyzed the similarities and differences between orchard proximity and local meteo stations in the temperature parameter, considering the influence on tree chilling and heat accumulation. The international meteo station, with almost 100 years of records, gave an image of the temperature changes. Until the 2000 year, the minimum, maximum, and, respectively, average annual temperature ranged in a specific interval. Since then, there has been an ascending trend, and there is a need to consider for the Bucharest area an average temperature of 11-12ºC and even 12-13ºC instead of 10-11ºC. Analyzing the monthly average values, an interesting finding was in the warm months, from April to October, where the temperature in time had a constant trend. January to March became warmer, and, with lower trends, November and December.

When temperature trends were compared between the international meteo station, placed 4 km from the orchard, and the local ones, maximum temperatures were similar, but minimum temperatures and the average were higher due to the city-protected effect.

Chilling accumulation quantity is essential in breeding programs, but not only. An overview of almost 100 years in the Bucharest region showed that there were no challenges with chilling hours/ portions necessary for the local species.

For the last years, all the stations showed similar chilling accumulation, but the local ones presented significantly higher values for heat accumulation (16%), which is essential for phenology models. Analyzing the monthly heat accumulation, February and March presented higher values in the last year, influencing earlier vegetation seasons.

ACKNOWLEDGEMENTS

This research was supported by the Ministry of Agriculture and Rural Development, financed through Project ADER No. 613/2023.

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