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Vlad Dragoslav MIRCOV*[1]*, Veronica SĂRĂȚEANU*, Casiana MIHUȚ, Daniela Sabina POȘTA, Carmen Claudia DURĂU

IMPACT OF EXTREME WEATHER CONDITIONS ON THE PRODUCTION OF THE MAIN FIELD CROPS IN WESTERN ROMANIA OVER THE 2018-2023 PERIOD – CASE STUDY

SUMMARY

From a climatic perspective, the Banat region falls within the temperate continental climate zone, influenced by sub-Mediterranean conditions resulting from the overlapping circulation of Atlantic air masses and Mediterranean air invasions. Along with Romania's geographical position with respect to the main pressure centres, the characteristics of the relief create great differences in terms of the genesis and distribution of atmospheric precipitation, both throughout the country and above south-western Romania. This area of the country is situated in a highly varied geographical setting, characterised by relief forms whose altitude increases from west to east, much like an amphitheatre. This climate generates a moderate climate from a thermal point of view, while the multiannual precipitation averages are high, specifically between 600 mm/year in the plain area and up to 1400 mm/year in the mountainous area. Certain climate changes have been noticeable over time, and their impact has also been felt in the western part of Romania.

The paper describes the most important meteorological aspects reported in the western and southwestern parts of the country, between 2018 and 2023, in relation to the average production of the main field crops.

Keywords: temperature, rainfall amount, multiannual averages, field crops, average yield.

INTRODUCTION

The climate in southwestern Romania is continental with Mediterranean influences (National Meteorological Administration, 2008). In this area, compared to other regions of the country, the cold season of the year is not particularly intense due to Mediterranean influences (Ardelean and Zăvoianu,

[1] Vlad Dragoslav MIRCOV, Veronica SĂRĂȚEANU* (Corresponding author email: veronica_sarateanu@usvt.ro), Casiana MIHUȚ, Daniela Sabina POȘTA, Carmen Claudia DURĂU, University of Life Sciences "King Mihai I" from Timișoara, Calea Aradului Street, no. 119, 300645, Timișoara, ROMANIA.

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1970; Munteanu and Munteanu, 1998) which make the snow cover shorter, the snow depth lower and the air temperatures higher, even in the cold season (Bogdan, 1978; Bogdan, 1983; Bogdan and Niculescu 1999; National Meteorological Administration, 2008).

Agricultural land in south-western Romania is characterised by the increase of the aridization phenomenon, which determines a decline in agricultural production (Prăvălie *et al.,* 2013).

Results from the literature reveal various aspects of the climate's influence on western Romania's soil characteristics and the production of specific agricultural crops (Mihuț *et al*., 2024) or on the productivity and vegetation of permanent grasslands, including their floristic composition (Sărățeanu *et al*., 2023).

The actions needed to adapt to climate change by the Romanian population, and thus farmers, are profoundly influenced by their perception of these phenomena (Cheval *et al*., 2022)

The aim of the study was to highlight the evolution of temperatures and precipitation during the period analysed and their impact on the average yields per hectare of the main agricultural crops in the area under study. The aim was to highlight the crops vulnerable to climatic variations and which jeopardise the financial stability of farmers, due to very high production losses in Timis County, according to the results obtained in the studied time interval.

shaping target strategies of preservation of forest biodiversity in different ecosystems.

MATERIAL AND METHODS

Data and maps from the archive of the National Administration of Meteorology (https://www.meteoromania.ro/) were used to analyse the climatic situation reflected on agricultural production. In addition, temperature and precipitation data from representative meteorological stations in Arad, Caras-Severin, and Timis counties, provided by the Regional Meteorological Centre Banat-Crisana for the period 2018-2023, were also presented and analysed. The monthly average data and multiannual averages (1901-2000) recorded at the Timișoara meteorological station were analysed in relation to the average yields per hectare obtained for the main agricultural crops grown in Timiș County.

Figure 1 shows a map of the main meteorological stations in southwestern Romania.

Information available in the Statistical Yearbook of Timis County (2023, 2025) was used to analyse the production data for the main agricultural crops.

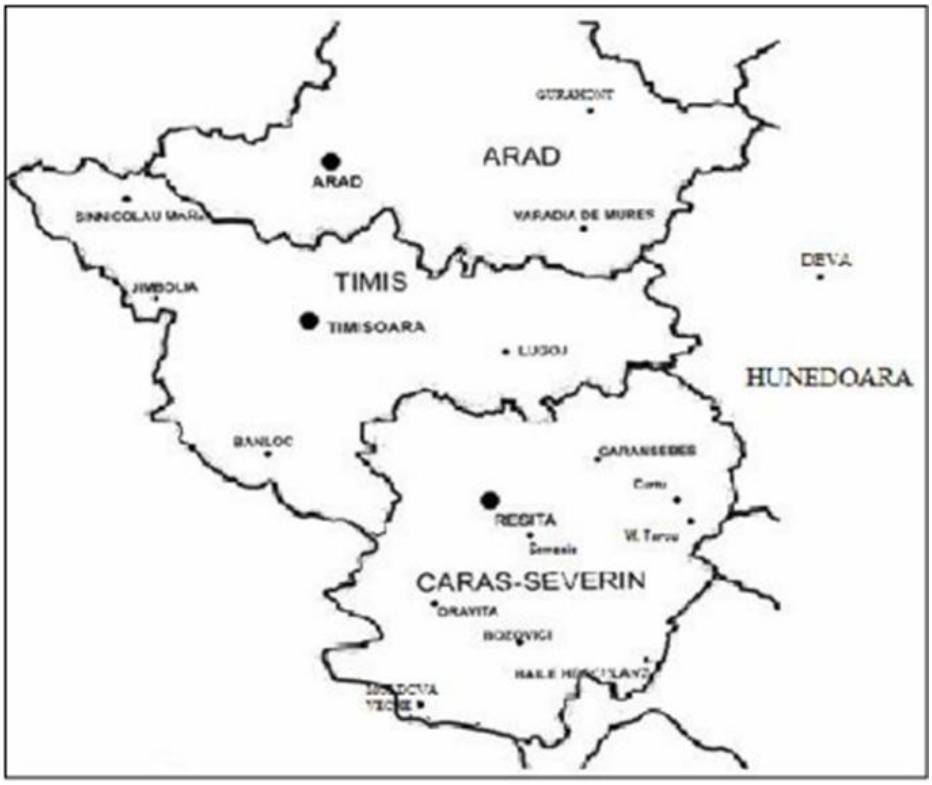


Figure 1. Map of meteorological stations in western Romania (Nichita, 2014)

RESULTS AND DISCUSSION

The climatic characteristics of the southwestern area of Romania were characterised by numerous episodes of extreme weather, which affected the yields of the main agricultural crops to varying degrees. The weather variations were general in the south-western part of the country, including the case analysed, i.e. Timis County.

The air temperature in Timiș County from 2018 to 2023 showed a higher increase compared to the multiannual average from 1901 to 2000 (10.7 °C), rising by 1.5 °C (2021) to 2.6 °C (2023) (Figure 2).

As can also be seen from Figure 2, temperature values have, almost without exception, exceeded the multi-annual monthly averages and the multi-year reference average during the analysed period, which clearly shows the warming of the weather compared to the reference period.

Even if the mean temperature values show increases compared to the averages, the analysed period was also characterised by episodes of extreme weather, according to data from the National Meteorological Administration and the Regional Meteorological Centre Banat-Crișana .

Thus, in the third decade of March 2018, at most stations in the three counties of southwestern Romania, a late winter episode with negative consequences for agricultural production occurred.

Between March 20 and 24, 2018, in some areas of Timis and Caras Severin counties, low temperatures were recorded, with maximum temperatures of 0 °C and minimum temperatures ranging from -7 °C to -8 °C.

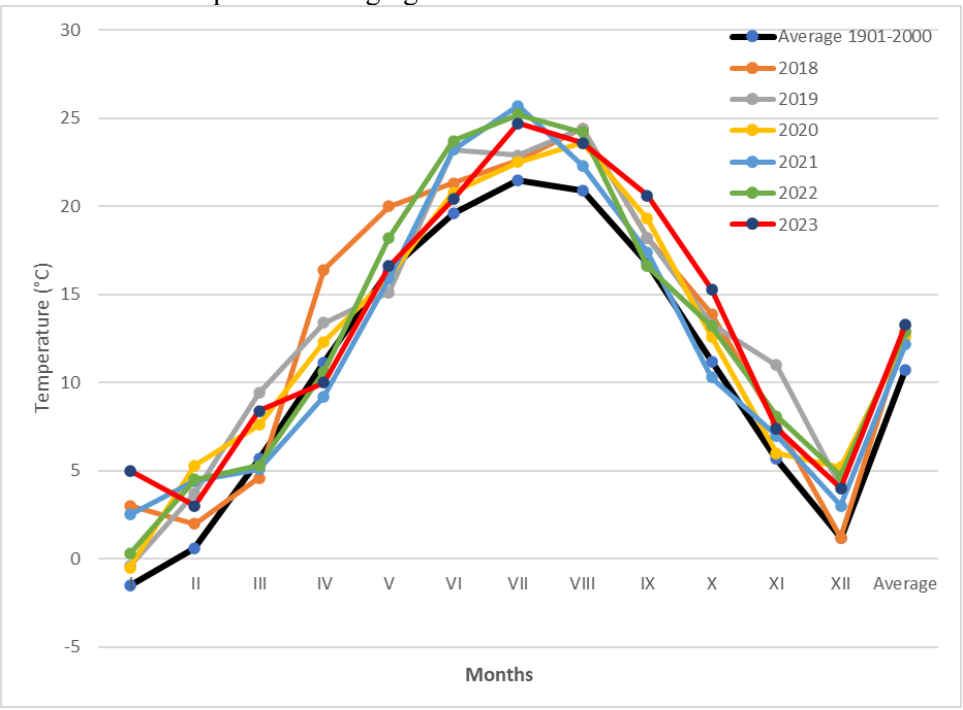


Figure 2. Monthly average air temperature (°C) and annual average during 2018-2023 compared with multiannual averages from 1901-2000 at Timișoara (data source: Regional Meteorological Centre Banat-Crișana)

Average temperatures were also negative, with deviations from the average ranging from -8 °C to -9 °C. In 2019, from a thermal point of view the only minimum value was -0.4 degrees C recorded in January. In 2020, the thermal regime was below the multiannual values at most stations in western Romania. Consequently, in Arad County, the average temperature in January was -1.3 °C, and the average in August was 22.3 °C. The year 2021 was the hottest year, with positive temperatures in winter, with an average of 1.9 °C recorded in January, and very hot in summer, with an average of 24.8 °C, the average value recorded in July. Temperatures of 35-36 °C were frequently recorded during this period. The year 2022 was characterised by relatively normal thermal values, with late spring frosts occurring in late March. The first three months of 2023 were characterised by warm weather, with average temperatures that were above multi-year averages. The month of April had average temperatures below the

multiannual mean temperature at all stations in the southwestern part of Romania, while the summer months recorded values 3 °C to 8 °C above the multiannual mean.

According to precipitation data from the Regional Meteorological Centre Banat-Crișana, recorded for Timis County between 2018 and 2023 (Figure 3), there is a noticeable change in the monthly averages compared to the multiannual average. In terms of the multi-year average of the annual precipitation sum between 1901 and 2000 is 583.9 mm. The difference in the analysed annual precipitation sum ranged from 40.4 mm (2021) to 124 mm (2019), except in 2023 when it was higher by 115.1 mm.

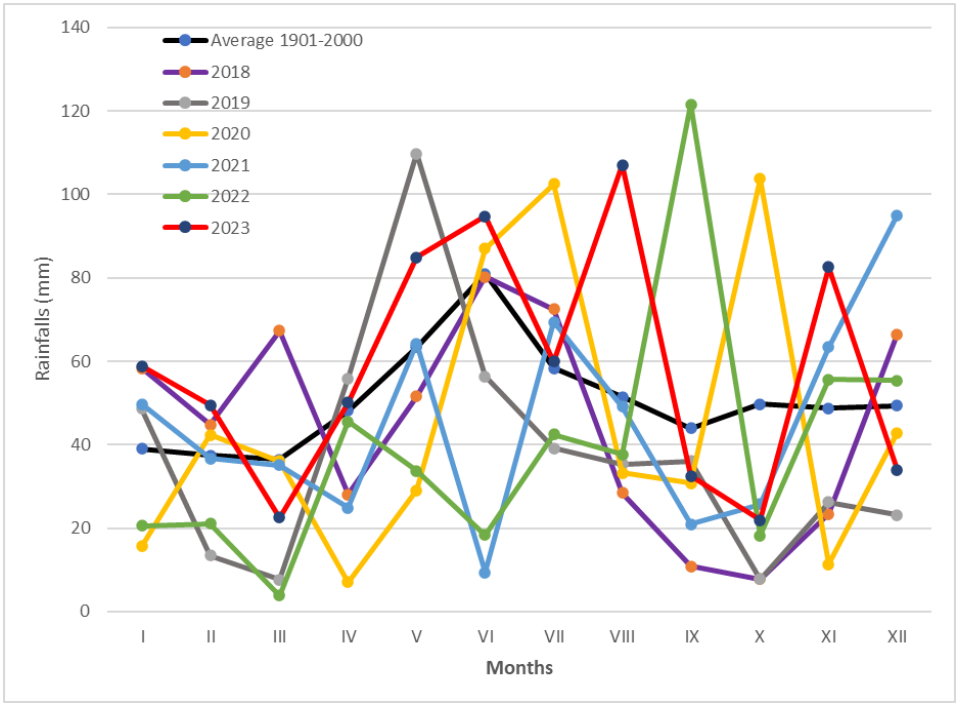


Figure 3. Monthly average rainfall amount (mm) and annual rainfall amount during 2018-2023 compared with multiannual average amounts from 1901-2000 at Timișoara (data source: Regional Meteorological Centre Banat-Crișana)

As can be seen from Figure 3, the biggest problem is the very sinuous distribution of precipitation from month to month and throughout the year, compared to multi-year averages, which is often also due to extreme weather episodes (very severe drought or very large amounts of precipitation falling in a very short time) that have an increasing frequency both during and outside the growing season. According to data from the National Meteorological Administration and the Regional Meteorological Centre Banat-Crisana, in 2018, the cold months were characterised by abundant precipitation, while late summer and autumn were dry periods.

Between March 20 and 24, 2018, snowfall was reported over relatively large areas, which also deposited a layer of snow; in some areas of Timis and Caras Severin counties, this layer was almost 20 cm thick. The second extreme episode occurred in December 2018, specifically on the evening of December 14, 2018, and lasted until noon on December 16. The snowfall area gradually expanded. Record snow cover thicknesses were reached, for example, in Timisoara there were 42 cm, compared to 40 cm, which was the previous record for December. In 2019, deficient precipitation was reported, especially in March and October. In both months, Timisoara received only 15.5 mm of rain. The maximum rainfall was recorded in May, with a value of 109.8 mm. At most meteorological stations in Timis and Arad counties, 2020 was a surplus year in terms of rainfall; this year, we have had two consecutive months with rainfall exceeding 100 mm. In June and July, Arad received 255 mm of rainfall, specifically 145 mm in June and 110.7 mm in July. In 2021, the southwestern area of Romania was characterised by severe drought in June, with a major impact on agriculture. The year 2022 was characterised by a deficient rainfall regime in the first five months, this being a dry year, according to the values recorded at all meteorological stations in the studied area. The year 2023 was generally characterised by excess precipitation compared to the multi-year average at most stations in southwestern Romania, especially in the summer months. However, the first months of the year were dry at some stations such as Sânnicolau Mare or Jimbolia.

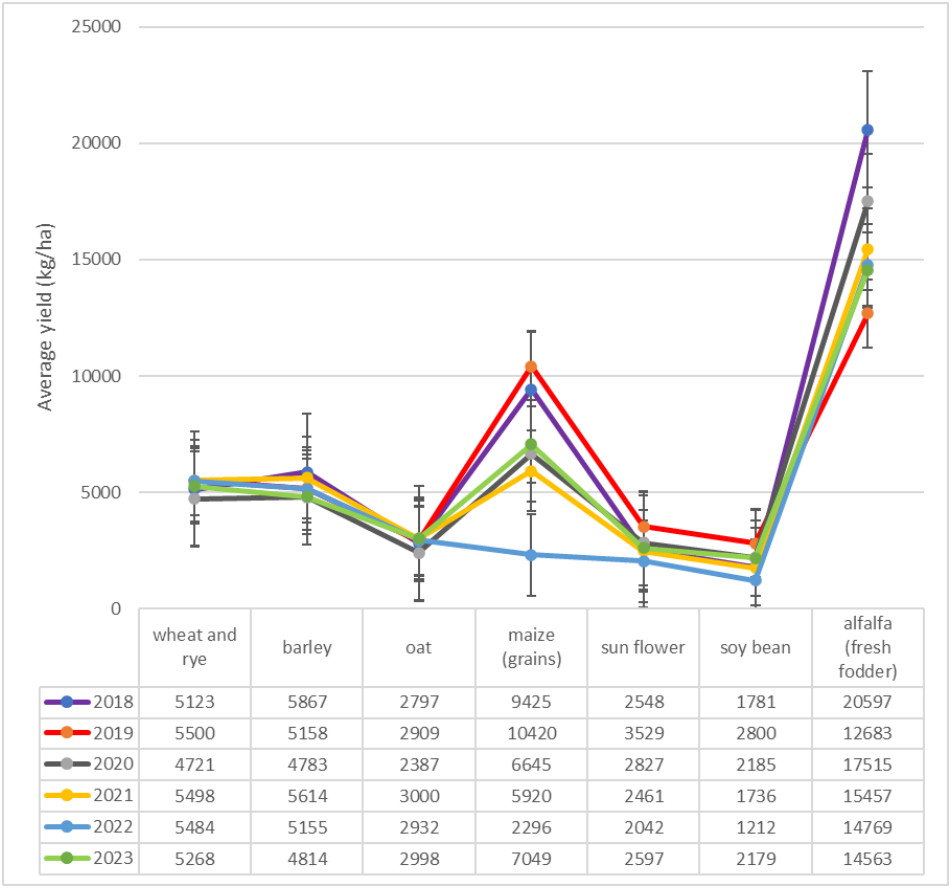
Concerning the average realised production data for the main crops in Timis County from 2018 to 2023, they are presented for wheat and rye, barley, oats, grain maize, sunflower, soybeans, and green table alfalfa (Figure 4).

In wheat and rye, the lowest average yield per hectare was recorded in 2020 (4,721 kg/ha), and the highest in 2019 (5,500 kg/ha). According to research by Harrison and Butterfield (1996), climatic changes are causing shifts in the zones of favourability for fall wheat cultivation.

In the case of barley, the lowest average yield per hectare was achieved in 2020 (4,783 kg/ha), while the highest was achieved in 2018 (5,867 kg/ha), resulting in a difference of more than one ton of grain per hectare between the minimum and maximum yields. In oats, the lowest average yield per hectare was achieved in 2020 (2,387 kg/ha), while the highest was recorded in 2021 (3,000 kg/ha). In the case of maize, results ranged dramatically between 2,296 kg/ha (2022) and 10,420 kg/ha (2019), with a difference of more than 8 t/ha between the two years. By far, this crop is the most affected by climatic variations and extreme weather events, which are increasingly frequent. Results obtained in the Czech Republic demonstrate the influence of temperature and precipitation, as well as the impact of climate change, on maize production. Research is needed to support the cultivation and maintenance of these plants (Maitah, Malec, & Maitah, 2021). Modelling by Reidsma *et al.* (2009) and Tovjanin *et al.* (2019) indicates a decrease in favourability for maize cultivation with increasing temperatures.

The sunflower crop had a minimum average production per hectare of 2,042 kg/ha in 2022 and a maximum of 3,529 kg/ha in 2019, the amplitude of these values in the analysed period being over 1,400 kg/ha, this also showing the vulnerability of this crop in the western part of Romania under the influence of climate change, as well as in other regions facing similar climatic phenomena (Harrison and Butterfield, 1996; Debaeke *et al*., 2017; Cvijanović *et al*., 2024).

Soybean crop recorded very high variations in production per hectare in Timis County in 2018-2023, thus the lowest average production was obtained in 2022 (1,212 kg/ha) and the highest in 2019 (2,800 kg/ha), the difference between the minimum and maximum average production being more than 1,500 kg/ha, which highlights the sensitivity of this crop to climatic variations in the analysed area. According to Nendel *et al*. (2023), the biggest risk for this crop is the increasingly frequent and prolonged drought; these results are also confirmed by Tovjanin *et al*. (2019) through the previously simulated models.



	wheat and rye	barley	oat	maize (grains)	sun flower	soy bean	alfalfa (fresh fodder)
2018	5123	5867	2797	9425	2548	1781	20597
2019	5500	5158	2909	10420	3529	2800	12683
2020	4721	4783	2387	6645	2827	2185	17515
2021	5498	5614	3000	5920	2461	1736	15457
2022	5484	5155	2932	2296	2042	1212	14769
2023	5268	4814	2998	7049	2597	2179	14563

Figure 4. Average yields (kg/ha) obtained in Timiș County in main field crops during 2018-2023 (source data Statistical Yearbook of Timiș County 2023 and 2023) (standard error displayed)

Lucerne, the most widely used forage crop in the world due to its extraordinary adaptability to widely varying environmental conditions (El-Ramady, 2020), has also suffered from increasingly frequent extreme climatic variations. Thus, the lowest green mass yield per hectare was obtained in 2019 (12,683 kg/ha), while the highest was recorded in 2018 (20,597 kg/ha). The difference between the minimum and maximum green mass production exceeds 7,900 kg/ha, which indicates that this crop is also vulnerable in the western area of Romania, given the evolution of climatic conditions characterised by increasing deviations from the multiannual average. El-Ramady (2020) questions the impact of climate change on global alfalfa cultivation, which could have a major impact on the world's main forage crop. In a long-term study (1990-2024) conducted in Hungary on the dynamics of fodder production in alfalfa crops, unfavourable climatic conditions, especially drought, are mentioned as a risk factor for production (Appiah, Kuunya, & Kutasy, 2025).

CONCLUSION

The mean annual temperatures recorded during the analysed time interval were much higher compared to the multi-year average. In terms of precipitation, almost all analysed years showed a water deficit compared to the multi-year average, except for 2023, when total precipitation was more abundant than the average.

The agricultural crops that showed the highest variation in production between 2018 and 2023 in Timis County were grain corn and green table alfalfa, followed by sunflower and soybeans. This suggests that farmers in the analysed region should select genetic material with high resistance to climatic variations or cultivate species more resilient to current climatic conditions to prevent economic losses and adapt to changing conditions. Such studies are needed to emphasise the need to decrease the participation of some crop varieties in cases of repeated poor production results and replace them with other complementary crops better adapted to current climatic conditions.

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