Scientific Papers. Series B, Horticulture. Vol. LXVIII, No. 1, 2024
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

CLIMATE CHANGES AND ITS EFFECTS ON SOILS AND AGRICULTURE IN WESTERN AND SOUTH-WESTERN ROMANIA

Vlad Dragoslav MIRCOV, Casiana MIHUȚ, Antoanela COZMA

University of Life Sciences "King Mihai I" from Timișoara, 119 Calea Aradului, 300645, Timişoara, Romania, Phone: +4025627475, Fax: +40256200296

Corresponding author email: casiana_mihut@usvt.ro; vlad_mircov@usvt.ro

Abstract

The paper refers to certain aspects of risk that have influenced the climate changes of the last two decades, especially after the year 2000. Updated data from the representative meteorological stations belonging to the Banat-Crișana Regional Meteorological Centre are presented. More extensive research was carried out in the case of thermal regime, pluviometric regime, and wind regime, regarding the evolution and deviations of these parameters in western and southwestern Romania compared to the national level. From 1960 until now, average temperatures have increased by up to 1.5°C in the Banat area and by 2-3°C in southern Romania, especially in the summer months. It is also worth noting the anomalies that occurred after 2000. At national level, 2019 was the warmest year. In the period 2012-2022, the most positive thermal anomalies were recorded (0.7-1.9°C), making it the warmest period of 10 consecutive years in the history of meteorological measurements recorded in Romania, with negative effects on soil cover and agriculture.

Key words: *climate change, thermal regime, pluviometric regime, soil cover, agriculture.*

INTRODUCTION

At the beginning of soil research, the theories supporting these phenomena were based on one or more pedogenesis factors, almost always different, a fact that favoured the emergence of a multitude of hypotheses or concepts Drăghici, 1988.

Among the first scholars who did research on soils were the ancient Greeks and Romans: Aristotle, Cato, Collumela, Hippocrates, Plinius, Varro, and Virgilius (Ianoş, 2004). Notions related to soil, still valid today, can also be found in treatises from the Middle Ages: Agricola (1494–1555), Lister (1683), Leonardo da Vinci (1452–1529), Paracelsus (1493–1541), while the first scientific work of scope was Agriculturae Fundamenta Chemica by the Swede Wallerius from Upsala (1761) (Bogdan & Niculescu, 1999).

Modern approaches to soil genesis processes, which integrate the soil into the set of environmental factors, arguing and quantifying the contribution of each external intervention, appeared much later, towards the middle of the 20th century (Brady & Weil, 2003; Cresser et al., 1993).

The explanation of soil formation cannot be limited to the interaction between the biosphere and the lithosphere, excluding geological processes. Thus, Erhart (1967), through his theory known as Biorhexistasia, stated that, "in geological times, successive periods of formation and destruction of the soil cover were distinguished. During periods of tectonic calm (biostasis), the soil cover was formed and evolved." During periods of imbalance (erosions, tectonic movements, volcanism), previously formed soils are destroyed (Sărățeanu et al., 2023). According to this theory, the soil cover evolved cyclically, with periods of interruption and resumption of the process, which explains its heterogeneity and diversity. This concept is supported by Gerrard (1981) who, quoting Butler, states that buried soils represent exactly the evolutionary cycles between the different phases of tectonic or climate instability (Alda et al., 2011; Barbu & Popa, 2003).

In Romania, in the study of soil formation and evolution phenomena, three distinct periods were identified: before 1906, between 1906 and 1948, and after 1948. Before 1906, pedological research was not organized and no well-defined concept was stated (Mihuț et al., 2022). It started with the chemical, physical, agro-geological conceptions, taken from Western Europe literature, then, after the International Congress of Geology in Petersburg in 1897, Matei Drăghiceanu brought to the country the

views of the Russian naturalist school which, gradually, took the place of the German agrogeological school views.
The initiator and organizer of the Romanian geographic-naturalistic soil genesis school was the geologist Gheorghe Munteanu Murgoci, who recommended studying the soil in close connection with the factors and processes of soilification. He stated that, to understand the formation and evolution of soils, the action of any factor should not be taken separately, independently of the action of the other factors (Mihut et al., 2022). In his view, the most important factors in the formation and transformation of soils were: parent rock, water, climate conditions, vegetation, and animals (Dobrei et al., 2016).
Climate influences both directly and indirectly the formation and evolution of soils through a complex of factors such as: temperature, precipitation, global radiation, cloudiness, relative humidity, evapotranspiration, etc. (Sircu, 1971; Tarca, 1998). Temperature influences the intensity of all soil processes: adsorption, alteration, mineralization, humification, evapotranspiration (Mahara, 1979; Mihailovici et al., 2000; Mircov et al., 2023; The climate of Romania, 2008).
The soils that form and develop in constant and uniform climate conditions are monogenetic – such as the soils of Banat formed after the last glaciation (Nichita, 2011).
The studies of Romanian researchers have contributed to the refinement of regional projection methodologies of the global warming signal (Povară, 2006). Statistical modelling methods applied to the results of global climate models were used, but also numerical experiments with regional climate models and the analysis of their results together with the observed data to highlight mechanisms by which local factors modulate the global signal of climate change (Pop, 1988; Posea, 2006).
Very short-term forecasting was done for small intervals of 12 hours up to 2-3 hours from where the nowcasting starts. The information underlying these weather forecasts was provided by the national radar system and the lightning detection system, images provided by meteorological satellites and information from automatic surface stations (Mircov et al., 2022).
Meteorological phenomena were permanently monitored by each Regional Weather Forecast Service and the Nowcasting Collective, elaborating forecasts for intervals of less than 12 hours, but also warnings regarding large amounts of precipitation, storms, or hail.
There was also the nowcasting which represents the provision of information about the occurrence of a meteorological phenomenon such as lightning, hail, heavy rains, wind intensifications. The amount of information provided by the nowcasting was conditioned by the ability to anticipate and detect the respective phenomenon. Lightning and tornadoes are phenomena that can be anticipated only minutes before they occur; however, their occurrence can be detected in real time with the help of lightning detectors and radars.
We constantly analyse climate fluctuations and we develop projections of the evolution of the climate system both on a large scale and on the scale of Romania, transferring scientific knowledge to the socio-economic environment through climate products and services.
From an agrometeorological point of view, February 1 is a reference moment for the start of thermal summations, since the analysis of the thermal oscillations of the last decades shows that the sporadic warmings (windows) during the month of February influenced the resumption of the vegetation cycle. Berbecel (1979) claims that, in 80% of cases, the resumption of the vegetative cycle in wheat begins in February.
For most cultures, Berbecel claims that the thermal index of de-springing is between 100°C and 500°C and it is achieved in the period February 1 II - April 10. Against the background of cold air invasions from the north-eastern areas of Europe, in the western part of Romania, especially in the hills, the last days with frost were reported in the second decade of April and very rarely later (Archive CMR Banat-Crișana).
Most authors, including Marchiș (2018), state that, "the temperatures characteristic of the spring season were particularly important because atmospheric conditions have a decisive influence on the state of vegetation of winter and spring crops, a fact that influences the beginning of the agricultural campaign".

In the southwestern part of Romania, the wind regime is determined by the development of baric systems that interfere over Europe at the latitude of 4500 N (Azoric, Siberian, Scandinavian anticyclones, and Mediterranean, Icelandic cyclones) (Moldovan, 2003; Munteanu, 2001; Nichita & Hauer, 2010).
Concerns regarding the soil mapping of some areas in Banat appeared relatively recently, after 1960. Based on the numerous information collected over the years, in 1993, Ianoş, Puşcă & Ţărău recreated the soil map of Timiş county on a scale 1:50,000. Ianoş (1994) first elaborated the map, after which Rogobete & Ţărău (1997), as well as Ianoş & Pușcă (1998) published the "Banat Soils Map" at a scale of 1:100,000, a synthesis of the work of several generations of pedologists grouped under the Office of Pedological and Agrochemical Studies from Timișoara (Mihuț & Niță, 2018).

MATERIALS AND METHODS

The purpose of this paper is to report certain meteorological interpretations on the thermal regime, the pluviometric regime and the wind regime characteristic of the western part of the country in the last twenty years (Drăghici, 1988; Ghibedea & Băcanu 1982; Mircov et al., 2017). Also, certain interpretations were made on synoptic maps. To best describe this aspect, we took into account the meteorological data provided by the Banat Crișana Regional Meteorological Centre, more precisely, the data from representative meteorological stations in Timiş, Arad, and Caraș-Severin counties. The more detailed analysis of certain phenomena was done to capture exceptions, special situations, or more significant meteorological elements (Mircov et al., 2023). For the climate characterization of the studied area, the records made at the level of the studied locality were also used (Archive CMR Banat-Crișana).
To achieve a correlation between the meteorological interpretations specific to the Western area of Romania and the influence these data have on the formation and evolution of soils and agriculture in general and for the best possible interpretation between the various studies carried out over the 20 years, it is necessary to detail the working methods and methodologies so that, in the future, comparisons can be made between the present results and those carried out according to other methods.
Regarding the soil study, a series of field trips were made, observations were made, soil samples were collected and soil properties were analysed, after which the data were processed according to the methodology in force. Given that the soil is a complex system that requires an increased diversity of methods and procedures for study, some general, others adapted from related sciences and others specific to the field. All study methods have a common starting point, namely - the elementary territorial entity of soil, which was investigated by soil researchers and especially by OSPA.
The analyses and other determinations were carried out in the laboratories of the Offices for Pedological and Agrochemical Studies in Timișoara and Arad.

RESULTS AND DISCUSSIONS

The soil cover in the western part of Romania presents the same arrangement in steps, from east to west, as the relief, the climate, or the vegetation. This characteristic is associated with the horizontal zonation of the soil cover, starting from the plain area, which gradually turns into a vertical zonation in the hill and mountain regions. This stepwise arrangement of the soils is primarily related to the formation of the relief in the western part of the country, through the appearance of dry land under the waters of the sea, from east to west. Because of this, the zonation of the soils follows the line of the meridians and is, generally, the same towards the piedmont and mountain area.
Table 1 presents the main soil types and associations of the studied area.

Table 1. Main types and associations of soils in Western Romania

No	SRTS - 2012
1.	Lithosol and folisol (di, eu, pr, rz)
2.	Regosol (di, eu, mo, um, li)
3.	Psamosol (eu, mo, gc)
4.	Aluviosol (en, eu, mo, gc, vs, sc, ac)
Protisols	
5.	Chernozem (ti, gc, ka,vs, sc, ac)
6.	Phaeosiom (ti, vs, gc, st, cl)
7.	Rendzine (li, cb, ka)
Chernisols	
8.	Eutricambosol (ti, mo, vs, ro, al)
9.	Districambosol (ti, um, ep, li)
Cambisols	
10.	Preluvosol (ti, mo, rs, vs, ca, st)
11.	Luvosol (ti, rs, ab, vs, pe, st)
12.	Planosol (ti, ab, vs, st)
Luvisols	
13.	Vertosol (ti, gc, st, br)
14.	Pelosol
Vertisols	
15.	Gleysol (eu, di, ka, mo, ce, ca, pe, al)
16.	Stagnosol (ti, lv, ab, vs, pl)
Hydrisols	
17.	Soloneţ (ti, mo, lv, ab, sc, gc)
Salsodisols	
18.	Erodosol (ca, cb, ar, sp, li)
Antrisols	

The southwest of Romania, like the whole country, due to its geographical position – in the temperate zone – is exposed to a wide range of meteorological and climate risk phenomena with the potential to occur throughout the year.
The purpose of this work is to identify some indicators that most correctly express the extreme nature of the manifestations of some meteorological parameters and their characterization in the 20-year interval, the 2018-2021 interval, it was noted by more accentuated anomalies within the pluviometric regime, and in the years 2017 and 2021, the wind regime was most evident in the south-western area of Banat, a region where the Coșava wind had an intensity of up to 100-110 km/h.
The main meteorological parameters from the representative stations in the south-west of the country were analysed to have an overview of the weather-climate characteristics. The more detailed analysis of certain phenomena was done to capture exceptions, special situations, or more significant meteorological elements.
The location of Romania in a certain context of action of the main baric centres imprints the temperate character of the climate. The location of the analysed territory in the south-western part of the country and the configuration of the relief define this character, imprinting sub-Mediterranean characteristics in the southern extremity and oceanic in the northern and eastern part of the area.
Figure 1 shows the map representing the entire hydrological network of the area.

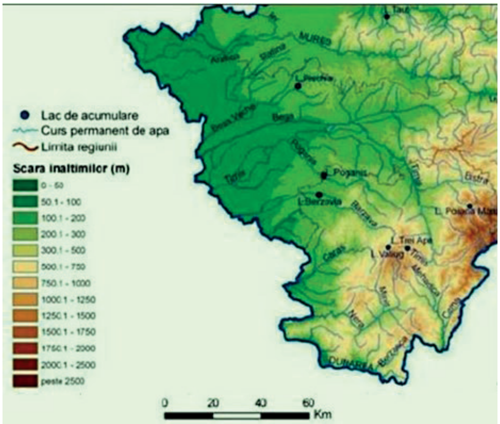
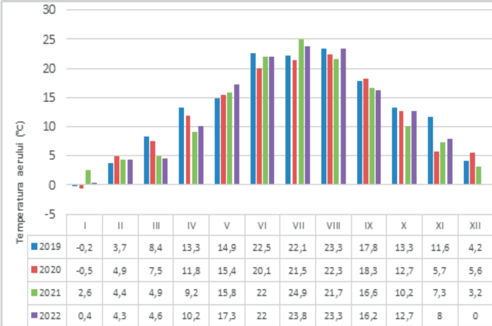


Figure 1. Map of the hydrographic network (from www.adrvest.ro)
(Legend: Permanent water course; Region limit; Height scale - m)

Knowing the weather-climate characteristics of the region is important for all areas of human activity and life, all extreme phenomena grafting on the main background of the mentioned weather-climate characteristics (Archive CMR Banat-Crișana).
Most of the climate indicators from the analysed period were presented for the Western part of Romania, considering the thermal regime, the pluviometric regime, and the atmospheric pressure.
The hottest month of the year was July, with average temperatures of 21^{0}C, and the coldest was January, when the average temperature reached 2^{0}C (Figure 2).
The annual average temperature variation has approximately the same value at all stations, the amplitude and values encountered differ. The highest values in the summer months were found at the southern stations, where the average temperature was over 22^{0}C at Moldova Veche and Banloc. The lowest average temperatures were recorded in the Bozovici depression area, where the temperature did not reach 20^{0}C (except for the stations in the mountain area).



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2019	-0,2	3,7	8,4	13,3	14,9	22,5	22,1	23,3	17,8	13,3	11,6	4,2
2020	-0,5	4,9	7,5	11,8	15,4	20,1	21,5	22,3	18,3	12,7	5,7	5,6
2021	2,6	4,4	4,9	9,2	15,8	22	24,9	21,7	16,6	10,2	7,3	3,2
2022	0,4	4,3	4,6	10,2	17,3	22	23,8	23,3	16,2	12,7	8	0

Figure 2. The evolution of the thermal regime in the period 2019-2022 from the town of Lugoj, Timiș county

From a thermal point of view, the climate specific to the western part of the country is also felt in this area, the hottest of the last studied years was also in Lugoj, a locality located 50 km from Timisoara, especially in the years 2019 and 2020. in November of 2019 we had frequent days with temperatures that exceeded 20^{0}C, and the monthly average for this month was 11.6^{0}C. Only in January was the monthly average negative, -0.2^{0}C, in January of 2019, respectively -0.5^{0}C, value recorded in the following year, in 2022. The summer of 2021 was the warmest, the highest monthly value was recorded in July, more precisely, 24.9^{0}C.

The month of January was the coldest month, with averages between 0 and -3^{0}C, the lowest value was recorded in the Bozovici Depression and in the Mureșului Corridor at the Vărădia de Mureș station, against an inversion background, and the highest values were recorded in the south, in Oravița and Moldova Veche. The mountain area recorded the lowest temperatures, a normal fact due to the altitude, the average in January reaching -8^{0}C in Țarcu.

For the analysed interval, in the analysed area, except for the mountainous area, records average values that exceeded 22^{0}C in the months of July, the highest value being registered in 2021, respectively 25.7^{0}C (Fig. 3).

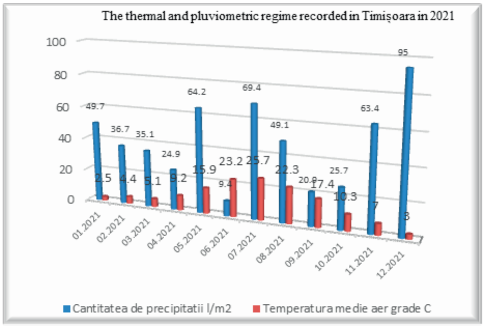


Figure 3. The thermal and pluviometric regime recorded in Timișoara in 2021
(Legend: amount of precipitation - l/m^2;
average air temperature degrees - ^{0}C)

In the studied region, spring was somewhat earlier and warmer compared to other areas of the country. Temperature oscillations occur with colder periods under the influence of air masses from the north and northeast, but also warmer periods due to the activity of Mediterranean cyclones. Thus, late frosts and isolated frost can occur on the coldest mornings even at the beginning of May, but hot days also occur in June. Also, in the spring, the first convective manifestations appear with stormy phenomena, torrential rains, and hail. Average temperatures gradually increase from 5-6^{0}C at the beginning of spring to 16-17^{0}C at the beginning of summer. Annual average values range from 7 to 11^{0}C.

Summer was dominated by formations related to the Azorean anticyclone and the Mediterranean cyclones, starting early, sometimes even in May and lasting until September. The average temperature of the hottest month was July and it varies between 21-22^{0}C in the Oravița-Moldova Veche area and 8^{0}C at high altitudes. Hot days occur with highs exceeding 35^{0}C and tropical nights with lows over 20^{0}C. For the analysed interval, it can be observed that, in Timişoara, in the month of July, the average values exceeded 22^{0}C, the highest value being registered in 2021, which was 25.7^{0}C. This year, 16 hot days were recorded in Timişoara in the summer months. Compared to 2021, in 2018 there were 11 hot days during the summer (Figure 4).

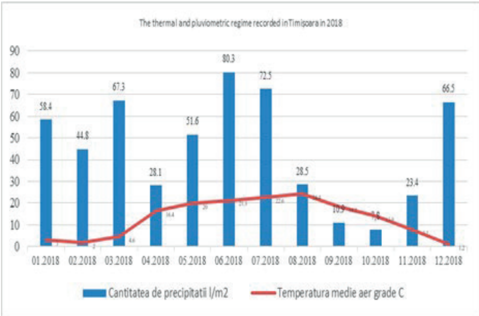


Figure 4. The thermal and pluviometric regime recorded in Timișoara in 2018
(Legend: amount of precipitation - l/m^2; average air temperature degrees - ^{0}C)

From the point of view of the pluviometric regime, it can be observed that the least precipitation in the analysed period was recorded in the months of October, November, and December of 2019, during which the precipitation reached only 57 l/m^2. This period also continued in the spring of 2020, a year in which in April there were only 7 l/m^2, and in May 29 l/m^2, which led to certain decreases in sunflower and maize crop production (Figure 5).

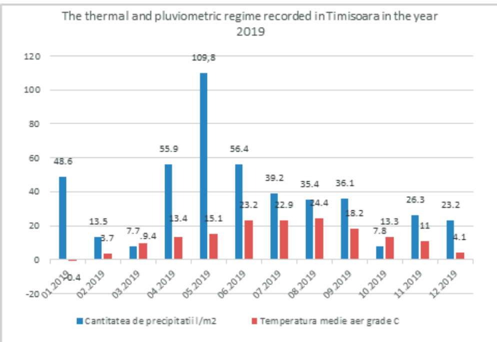


Figure 5. Thermal and pluviometric regime recorded in Timișoara in 2019
(Legend: amount of precipitation - l/m^2; average air temperature degrees - ^{0}C)

Starting from June 2020, when values of 87 l/m^2 were recorded and until October, the rainfall regime reached 356 l/m^2, while in two months, July and October, it rained over 100 l/m^2 (Figure 6).

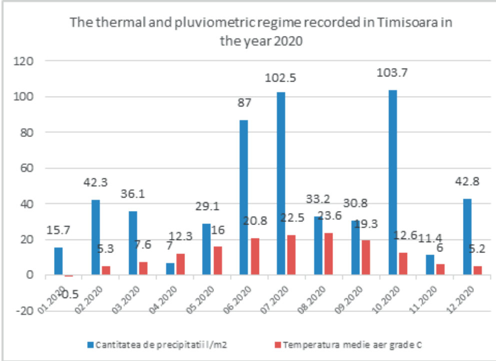


Fig. 6. Thermal and pluviometric regime recorded in Timișoara in 2020
(Legend: amount of precipitation - l/m^2; average air temperature degrees - ^{0}C)

For the analysed interval, a decrease in the rainfall regime in Timişoara was observed, the average slightly exceeded 510 l/m^2, the driest year being 2019, a year in which it rained a little over 460 l/m^2. The exception was May with 109 l/m^2, after which a dry period followed until November, a month in which 26 l/m^2 were recorded.

The annual values of the atmospheric pressure in Timişoara give a multiannual average of 984.4 mb, the atmospheric pressure at the station level, i.e. the pressure read at the barometer, to which temperature and gravity corrections have been applied. In 2018 and 2020, an average below the value of 980 mb was recorded, which means a more intense cyclonic activity and, implicitly, a higher number of cases for the respective years with manifestations of the wind (Figure 7).

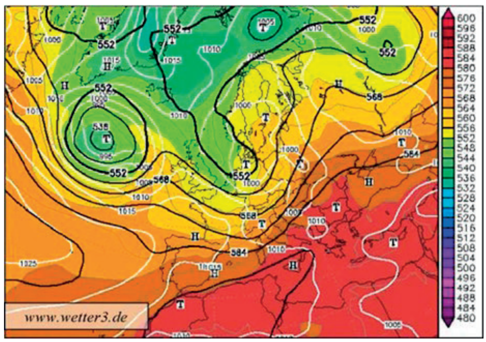


Figure 7. Ground atmospheric pressure and geopotential at 500 hPa

The shining duration was an indicator that represents the time interval during a day in which the sun shone on the sky. This consists of determining the number of hours during which the sun lighted the meteorological platform and its surroundings and depends on cloudiness, latitude, season, and altitude. The annual average was around 2,000-2,100 hours, an interval also found in the analysed period. The maximum annual value reached over 2,500 hours in 2000 in Timișoara, and the minimum 1,580 hours in Reșita in 1980. The highest average value was recorded in July or August and the minimum in December, less often in January. The most hours of sunlight were recorded in July 1963, in Timișoara, 290 hours to be exact.

The factors that determine the frequency and speed of the wind are related to the general circulation of the atmosphere, to which are added the influences of the local circulation. The magnitude of baric and thermal gradients related to baric formations, convection, all influence wind speed. Westerly winds predominate, with particularities determined by the above factors. Atmospheric calm prevails, in percentages varying between 21.5% in Sânnicolau Mare and 66% in Vărădia de Mureș.

In the images below (Figures 8 and 9), the wind rose for two representative stations from Caraș-Severin county, the one from Herculane and the one from Bozovici, respectively from Timiş county, the Sânnicolau Mare station, and the one from Lugoj are presented; Figure 10 shows graphically the relative humidity (%) of some more representative years from the studied period, namely the years 2002, 2007 and 2014.

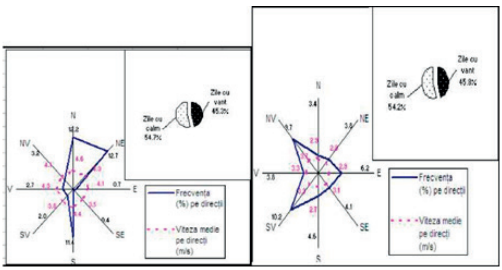


Figure 8. Win rose in Herculane and Bozovici (after, Nichita, 2011)

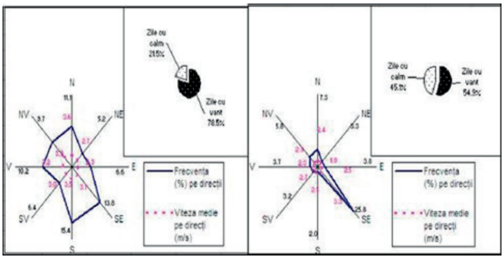


Figure 9. Win rose in Sânnicolau Mare and Lugoj (after Nichita, 2011)

From the images presented, the predominant wind direction was SE at Lugoj, while at Herculane the prevailing direction was N and NE.

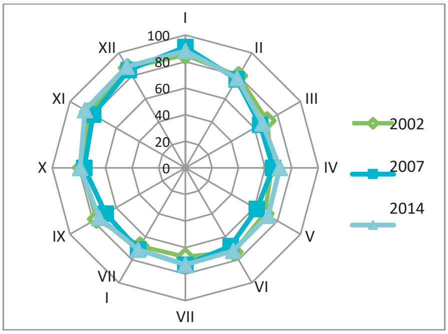


Figure 10. Graphical representation of relative humidity (%) in the years 2002, 2007 and 2014 at Timişoara Meteorological Station

Figure 10 shows how the relative humidity recorded at the Timişoara Meteorological Station had values between 20-60%. It kept on like that: higher values were found in the winter than in the summer, when the values decreased by a few percents.

CONCLUSIONS

The analysis of the climate conditions in the western part of Romania highlights the following aspects:

- The Banat area constitutes a favourable environment for the development of most agricultural crops specific to this latitude and altitude;
- Large temperature fluctuations between day and night, during winter and at the beginning of spring, cause great damage to fruit trees;
- In dry years, with high temperatures, plants suffer from temporary withering;

- In the spring, late frosts were harmful, which surprise the still undeveloped plants and which also affect the orchards;
- The amount of precipitation, even if it is sufficient, in most years has an uneven distribution (there were periods of drought even in the critical phases of vegetation development), affecting the growth of crops;
- Torrential rains were more frequent in the months of May and June, when they cause much more damage, compared to the rest of the year;
- Except for the area around Timișoara, the winds have low frequencies and intensities, which does not require the planting of protective curtains;
- The relative humidity values allow the successful cultivation of vegetables, fruit trees, vines, and crops;
- Soil fertility and their productive capacity intervene in the genesis process and influence the favourable environmental conditions for the growth and development of plants;
- The heat from the soil surface leaves its mark on the intensity of evaporation from the soil surface and is necessary to consider when measuring the rate of evapotranspiration;
- The precipitation, close to the average value at the level of the country, supplies the soil with water and it acts, depending on the local conditions, on specific soil genesis processes such as: eluviation, illuviation, pseudo-gleysation, in different ways (percolation, stagnation, silting, draining);
- The combined action of temperature and precipitation influenced the formation of clay minerals in soils, so that, over time, the proportion of resulting clay minerals increased proportionally with humidity and exponentially with temperature;
- The gaseous phase occupies a percentage of 5-40% in the soil, lower in the compacted and finely textured soils and maximum in the loose and coarsely textured soils of the area;
- The soil reflects the climate condition through the way and intensity of alteration of the mineral part, through the leaching intensity of some mineral constituents or through the nature and intensity of the decomposition of organic matter.

Thus, there was great non-periodic variability of dryness and drought in frequency, duration, and intensity. According to the opinion expressed by Bogdan (1980), 22 periods of drought occurred in the Western Plain. In the relatively small number of drought periods compared to other regions of the country, an important role was played by the geographical location of the Banat area in relation to the main air masses that affect Romania.

As mentioned in the paper, with regard to the precipitation values during the analysed period, recent examples of drought were reported in the spring of 2007, when several weather stations accumulated amounts of less than 1 l/m^2 in April or at the end of the autumn of the year 2011.

The annual average was around 2,000-2,100 hours, the annual maximum can reach over 2,500 hours as in 2000 in Timișoara, and the minimum 1,580 hours in Reșita in 1980. The highest average value was recorded in July or August and the minimum in December , less often in January. The most hours of sunlight were recorded in July 1963, in Timișoara: 290 hours.

The factors that determine the frequency and speed of the wind are related to the general circulation of the atmosphere, to which are added the influences of the local circulation. The magnitude of baric and thermal gradients related to baric formations, convection, all influence wind speed. Westerly winds predominate, with particularities determined by the above factors. Atmospheric calm prevailed, in percentages varying between 21.5% in Sânnicolau Mare and 66% in Vărădia de Mureș.

Romania's relief configuration and Mediterranean influences mean that the average number of days with blizzards was very low. In 30 years, the average number of days per year was less than 1.

In the mountain area, the average started from 9.8 days and exceeded this figure in Țarcu, by 21 days.

The most snow days were recorded in the cold season of the year and in the mountain areas, where they occurred in all seasons of the year, with the highest frequency in January and December.

In the southwestern area of Romania, the annual average number of days with frost varied between 60 and 90 days in the hill and plain areas and fell below 50 days in the mountains.

On average, the first frosty days appeared in the plains in the second half of October and the last frosty days in mid-April. For example, in Timișoara, the first fog was reported on average around October 16 and the last on April 16.

ACKNOWLEDGEMENTS

This paper is published from the project 6PFE of the University of Life Sciences "King Mihai I" from Timisoara and Research Institute for Biosecurity and Bioengineering from Timisoara

REFERENCES

Alda S., Lăzureanu A., G Cârciu, L Ni ă, L Alda, T Cristea, M Danci (2011). Quality evaluation of some maize hybrids cultivated under pedoclimatic conditions of Banat area (West of Romania), *Journal of Horticulture, Foretry, and Biotechnology* 15(2), pp. 48.

Barbu, I., Popa, I. (2003). *Monitoringul secetei în padurile din România.* Edit. Tehnica Silvica, Câmpulung Moldovenesc, 128 p.3.

Bogdan, Octavia, Niculescu, Elena (1999). *Riscurile climatice din România*, Ed. Sega-International, București, pp. 56.

Brady, N.C. & Weil, R.R. (2003). Elements of the Nature and Properties of Soils (2nd edition), Upper saddle River, NJ: Prentice-Hall, Inc., pp.36.

Cresser, J., Killham, N., Edwards, J. (1993). Soil chemistry and its application, Cambridge, pp.65.

Dobrei A., Gheorghe Posta, Marcel Danci, Eleonora Nistor, Dorin Camen, Mihaela Mălăescu, Florin Sala, (2016). Research concerning the correlation between crop load, leaf area and grape yield in few grapevine varieties - *Agriculture and Agricultural ScienceProcedia,* pp. 45.

Drăghici, I., (1988). *Dinamica atmosferei*, Editura Tehnică, București, pp. 62.

Ghibedea, V., Băcanu, Lucia (1982). *Vântul Coșava – monografie*, Facultatea de științe econimice, Timișoara, pp. 135.

Ioana Marchiș, Iulia Sopca, Raluca Perescu, Casiana Mihuț, V.D. Mircov (2018). The role of climate factors in the genesis of soil resources at Livezile, Timis County, Romani. *Research Journal of Agricultural Science*, 50 (4), 2018, pp. 213-217.

Măhară, Ghe. (1979). *Circulația aerului pe glob*, Editura Științifică și Enciclopedică, București București.

Mihajlovici D.T., Mircov D.V., Branislava Lalici, Arsenici I. (2000). *Bazele observațiilor meteoro-logice și a prelucrarii datelor*, Ed. Eurostampa, Timișoara, pp. 84.

Mihuț, Casiana & Niță L. (2018). Atmospheric factors used to characterize soil resources. *Research Journal of Agricultural Science,* 50 (1), 2018, 143-146.

Mihuț, C., Mateoc-Sîrb, N., Duma Copcea, A., Niță L., Ciolac, V., Okros A., Popa D. (2022). Assessment of soil quality limitative factors. A case study: Secaş, Timiş County, Romania. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development* Vol. 22, Issue 1, pp. 413-419, WOS:000798307300049. PRINT ISSN 2284-7995, E-ISSN 2285-3952.

Mircov V.D., Okros, A., Mihut, C.D., Duma Copcea, A., Chis C. (2023). Interpretation of climate risk factors for the period 2019-2022 in the Western Area Of Romania. *International Multidisciplinary Scientific GeoConference*: SGEM. Volumul 23 No. 4.1, pg. 301-306

Mircov V.D., Okros, A., Mihut, C., Ciolac, V., Durău, C.C. (2022). Climate assessment and risk analysis in Western and Northwestern Romania. *International Multidisciplinary Scientific GeoConference*: SGEM 22 (4.1), pp.303-308.

Mircov V.D., Nichita, C., Okros, A., Nicolin, A., Barliba C. (2017). The relationship between climatic extremes from 2016-2017 in the Western Romania. *International Multidisciplinary Scientific GeoConference*: SGEM 17, pp.561-568.

Moldovan, F., (2003). *Fenomene climatice de risc*, Editura Echinox, Cluj-Napoca;

Munteanu, Rodica, (2001), *Geografia fizică a României*, Editura Mirton, Timișoara;

Nichita, C., Hauer, Elza (2010). A low level jet case study in the southern part of Banat, Romanian *Journal of Meteorology*, vol.10, nr.2/2010, București.

Nichita, C. (2011). *Utilizarea radarului doppler în gestionarea fenomenelor meteorologice periculoase în sud-vestul României* - teză de doctorat, Universitatea de Vest din Timișoara

Patriche, C.V. (2009). *Metode statistice aplicate în climatologie*, Editura Terra Nostra, Iași

Pop, Ghe. (1988). Introducere în meteorologie și climatologie, Editura Științifică și Enciclopedica, București.

Posea, Gr. (2006). *Geografia fizică a României*, Editura Fundației România de Mâine, București.

Povară, Rodica (2006). *Meteorologie generală*, Editura Fundației România de Mâine, București.

Sărățeanu, V., Cotuna, O., Paraschivu, M., Cojocariu, L., Horablaga, N.M., Rechițean, D., Mircov, V.D., Sălceanu, C., Urlică, A., Copăcean L. (2023). Features of Natural Succession of Ex-Arable Forest Steppe Grassland (from Western Romania) under the Influence of Climate. Plants 2023, 12(6), 1204; https://doi.org/10.3390/plants12061204

Sircu, I. (1971). *Geografia fizică a R.S.R.,* Editura Didactică și Pedagocică, București.

Ţarcă, M. (1998). *Tratat de statistica aplicata*. Edit. Didactica si Pedagogica, Bucuresti, 808 p.

***(2008), Clima României, Administraţia Naţională de Meteorologie, Bucureşti;

***Arhiva Centrului Meteorologic Regional Banat-Crișana din Timișoara.

www.adrvest.ro