Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 2, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE CLIMATE VARIABILITY OF THE YEAR 2019 AND THE IMPACT ON THE MAIZE PRODUCTION IN THE SOUTHERN-WESTERN DEVELOPMENT REGION OF OLTENIA, ROMANIA

Dana Maria (OPREA) CONSTANTIN[1], Ion MARINICĂ[2], Andreea Floriana MARINICĂ[3], Elena GRIGORE[1], Florina TATU[1], Gabriela DÎRLOMAN[4], Dan Vasile ARDELIAN[5]

[1]The University of Bucharest, The Faculty of Geography, 1 Nicolae Bălcescu Avenue, 010041, District 1, Bucharest, Romania, Emails: danamartines@yahoo.com, elazigzag@gmail.com, foleaf@yahoo.com
[2]The University of Craiova, The Faculty of Science, 13 A.I. Cuza Street, 200585, Craiova, Romania; Email: ionmarinica@yahoo.com
[3]Klimacampus, Hamburg, Germany, Email: marinica.andreea@gmail.com
[4]"Nicolae Kretzulescu" Commercial High School, 17 Hristo Botev Avenue, District 3, Bucharest, Romania, Email: gabriela.dirloman@gmail.com
[5]The University of Bucharest, The Faculty of Geography, "Simion Mehedinți" Doctoral School, 1 Nicolae Bălcescu Avenue, 010041, District 1, Bucharest, Romania, Email: dan-vasile.ardelian@drd.unibuc.ro

Corresponding author: danamartines@yahoo.com

Abstract

In the current context of the global warming, knowing the impact on different economic sectors can be achieved by analyzing the climate variability in both short and long term. The agricultural production is closely linked to short-term climate variability at the year level. The main purpose of the study is to analyze the temperature and precipitation regime of the year 2019, for the Southern-Western Development Region of Oltenia, in relation to the bio-climatic requirements of the maize. The year 2019, in Romania, is the warmest year from 1900 to present, according to the National Meteorological Administration (NMA). The analysis of the thermic and precipitation resources will be performed based on the meteorological-climatic data from 15 meteorological stations belonging to the National Meteorological Administration. There will be used statistical methods and GIS techniques, complemented by using the Hellmann classification for establishing the types of the thermic and precipitation weather type of the year 2019. According to this classification, the year 2019 in the study area, was a warm and normally rainy year on average. Based on these variations of the temperature and precipitation regime, at the level of the study area, there was an average production per hectare of grain maize of 5,707 kg/ha, with 1,647 kg/ha less than in 2018, which was considered a record production year from 2000 to 2020.

Key words**:** *thermic regime, pluviometric regime, climate variability, maize, the Southern-Western Development Region of Oltenia*

INTRODUCTION

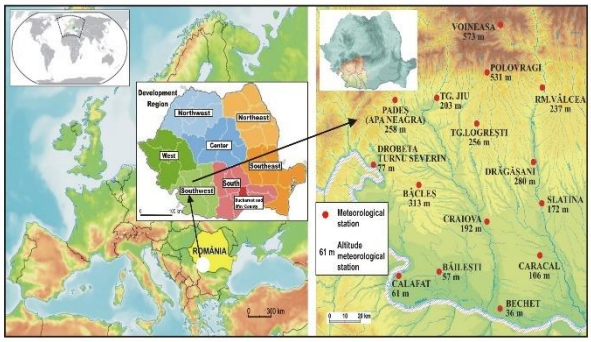
The year 2019 has continued the series of the exceptional warm years, starting with 2015 [8], being the second warmest year after 2016, compared to the average of the pre-industrial period 1850-1900 at global level [12]. In Romania, 2019 ranked first in the top of the warmest years, for the period 1900-2021 [3]. In Oltenia, the recorded annual average temperature recorded was 12.4°C, with a positive deviation of 2.5°C compared to the period 1901-1990, confirming the characteristic of a warm year. All these thermic aspects confirm the continuation of the global warming and the need of sustainable measures for the socio-economic adaptation to the new climate context.

Knowing the impact of the climate variability on the growth, development and formation of the agricultural crops represents a compulsory condition for the implementation of a good agricultural management [7; 10].

The Southern-Western Development Region of Oltenia is characterized by a continental temperate climate, with altitudes between 18

m (at the South) and 2,519 m (at the North) and represents 12% of Romania's surface (Map 1) [5].

The main purpose of this study is to analyze the influence of the air temperature and precipitation variability on vegetation and maize yields in the Southern-Western Development Region of Oltenia, for the year 2019. Maize is one of the important spring crops of Romania, which has different requirements for air temperature and precipitation during the growing season. The maximum requirements for both air temperature and precipitation water consumption are the monthly interval of July-August [10].



Map 1. The location of the study area and of the meteorological stations.
Source: own processing from GIS open sources.

MATERIALS AND METHODS

The analysis of the temperature and precipitation resources will be performed, based on the meteorological-climatic data from 15 meteorological stations (MS), belonging to the National Meteorological Administration (NMA). These meteorological stations are representative for the study area, having altitudes between 36 m and 573 m (Map 1).

The monthly air temperature and precipitation data were compared with the values from 1901-1990 (reference period) in order to identify the thermic and precipitation weather types for the year 2019, according to the Hellmann criterion [6]. The analysis of the thermic resources is completed by the analysis of the maximum and minimum air temperature for each month. The characteristics of the thermic and precipitation regime of a year are reflected in the state of vegetation and in the yields of the crops [9]. In order to capture this aspect, the yields data and the cultivated areas with maize from the National Institute of Statistics (NIS) will be analyzed. These data are analyzed using statistical methods and GIS techniques.

RESULTS AND DISCUSSIONS

The analysis of the temperature regime

January has the lowest average temperature in the year, with values between -2.9°C at Voineasa and 0.9°C at Calafat, being a slightly warm month, according to the Hellmann criterion, in most part of the study area (Table 1).

Table 1. The matrix of the thermic time types recorded in the Southern-Western Development Region of Oltenia, in 2019, after Hellmann Criterion

MS	Months					
	I	II	III	IV	V	VI
Dr. Tr. Severin	W	W	W	SW	N	W
Calafat	W	W	W	N	N	W
Bechet	SW	W	W	N	N	SW
Băilești	SW	W	W	N	CO	SW
Caracal	W	W	W	N	N	W
Craiova	SW	W	W	N	N	SW
Slatina	SW	W	W	N	N	SW
Bâcleș	SW	W	W	N	N	W
Tg. Logrești	N	W	W	N	N	W
Drăgășani	SW	W	VW	N	N	W
Padeș (Apa Neagră)	N	SW	W	N	N	W
Tg. Jiu	SW	W	W	SW	N	W
Polovragi	SW	W	W	N	N	W
Rm. Vâlcea	SW	W	W	SW	N	W
Voineasa	SW	W	W	SW	N	W
Oltenia average	**SW**	**W**	**W**	**N**	**N**	**W**
MS	**Months**					
	VII	**VIII**	**IX**	**X**	**XI**	**XII**
Dr. Tr. Severin	SW	W	W	W	W	W
Calafat	SW	W	W	SW	W	W
Bechet	N	SW	SW	N	W	W
Băilești	N	W	W	W	W	W
Caracal	N	W	W	W	W	W
Craiova	N	W	W	W	W	W
Slatina	N	W	SW	W	W	W
Bâcleș	N	W	W	W	W	W
Tg. Logrești	N	SW	SW	N	W	W
Drăgășani	N	W	W	W	W	W
Padeș (Apa Neagră)	N	W	SW	N	W	W
Tg. Jiu	N	W	SW	SW	W	W
Polovragi	N	W	SW	W	W	W
Rm. Vâlcea	N	W	W	W	W	W
Voineasa	N	W	SW	SW	VW	W
Oltenia average	**N**	**W**	**SW**	**SW**	**W**	**W**

EC – excessively cold; VC – very cold; CL – cold; CO – cool; N – normal; SW – slightly warm; W – warm; VW – very warm; EW – excessively warm.

Source: NMA archive for temperature and precipitation values.

The average temperature in January, for the entire study area, was -1.0°C. Its thermic deviation from the reference period was 1.6°C, being a slightly warmer (SW) month, in average, according to the Hellmann criterion (Table 1). The monthly maximum air temperatures were registered between January 16th and January 18th and they were between 8.2°C at Padeș and 14.3°C at Calafat. The monthly minimum air temperature was recorded between January 5th and January 14th, being between -17.3°C at Padeș and -9.3°C at Dr. Tr. Severin.

February was characterized by a monthly average temperature between 0.1°C at Voineasa and 4.1°C at Drăgășani, being, according to Hellmann criterion, a warm month in the whole study area, except the Padeș MS area, where there was a slightly warm month (Table 1). The maximum values of the air temperature varied between 14.8°C at Voineasa and 18.5°C at Calafat and Drăgășani, in the interval between February 18th and February 20th. The monthly minimum temperatures were between -17.2°C at Padeș and -7.6°C at Caracal.

The spring months of 2019 were characterized by an alternation of normal days, in terms of temperature, with intervals in which the weather was warmer than usual [1]. The monthly average air temperature of March recorded values between 5.1°C at Voineasa and 10.4°C at Calafat, being a warm (W) month in most of the study area, except for Drăgășani MS where there was a very warm (VW) moth, according to Hellmann criterion (Table 1). April was characterized by a monthly average temperature ranging between 8.7°C at Voineasa and 13.1°C at Dr. Tr. Severin, and the average for the entire study area was 11.9°C, being a normal (N) thermic month, according to Hellmann criterion (Table 1). The highest values of the air temperature were recorded in the last five days of the month, being between 23.8°C at Polovragi and 27.7°C at Bechet. The lowest air temperature values were between -2.0°C at Voineasa and 3.0°C at Dr. Tr. Severin. May was a normal thermic month (Table 1) in most parts of the study area, with monthly averages of the air temperature between 12.6°C at Voineasa and 17.1°C at Bechet. The monthly average air temperature calculated for the entire study area was 15.8°C and its deviation from the reference period was -0.2°C, which confirms a normal thermic time, according to the Hellmann criterion (Table 1). The highest temperatures in May varied between 24.6°C at Polovragi and 31.0°C at Bechet and the minimum temperatures ranged between -0.4°C at Voineasa and 3.0°C at Dr. Tr. Severin.

The summer months of 2019 were characterized by warmer weather than usual [1]. June was characterized by average temperatures between 17.6°C at Voineasa and 23.5°C at Bechet, being a warm (W) month in most of Oltenia (Table 1). The maximum temperatures exceeded 30.0°C at Bâcleș meteorological stations (31.1°C) and Calafat (34.7°C), and the minimum temperatures recorded values between 8.0°C at Voineasa and 13.8°C at Calafat. July 2019 was a normal thermic month in most parts of the study area (Table 1). The monthly average temperatures varied between 17.2°C at Voineasa and 24.5°C at Calafat and the monthly average value for the entire study area was 22.1°C. The highest air temperature values were recorded at Polovragi (31.7°C) and Bechet (38.1°C). The minimum temperatures ranged between 5.5°C at Voineasa and 13.2°C at Calafat.

August 2019 was characterized by monthly average values between 18.5°C at Voineasa and 25.9°C at Dr. Tr. Severin, being a warm month for most parts of the study area (Table 1). The maximum temperatures ranged between 32.5°C at Polovragi and 38.2°C at Bechet and the minimum temperatures were between 6.9°C at Padeș and 14.2°C at Calafat.

In the autumn months, a higher than usual air temperature prevailed in most parts of the country [2]. As a result, in most of the study area, the fall of 2019 was slightly warm (Table 1). September was slightly warmer (SW) than most of the area, as evidenced by the values of the average air temperature that ranged between 13.9°C at Voineasa and 20.7°C at Dr. Tr. Severin. In the first days of

the month, the maximum monthly values were recorded, which varied between 29.1°C at Voineasa and 34.6°C at Bechet. The minimum monthly air temperature was between -1.5°C at Padeș and 5.8°C at Dr. Tr. Severin. According to the Hellmann criterion, October was normal thermic on restricted areas at Padeș, Tg. Logrești and Bechet meteorological stations, slightly warm (SW) at Voineasa, Tg. Jiu and Calafat and warm (W) in the rest parts of the study area. The monthly average air temperature for the whole Oltenia region was 12.7°C, with a deviation from the reference period (1901-1990) of 1.9°C, which indicates a slightly warm (SW) month for the study area (Table 1). In terms of the maximum monthly air temperature values, there were recorded values between 25.1°C at Voineasa and 32.0°C at Bechet. The monthly minimum air temperature was between -2.7°C at Voineasa and 4.7°C at Dr. Tr. Severin.

November, according to Hellmann criterion, was a warm (W) month in most parts of the Oltenia region (Table 1). The monthly average air temperature values ranged between 7.3°C at Voineasa and 10.5°C at Dr. Tr. Severin. The maximum monthly values were between 18.0°C at Padeș and 25.5°C at Polovragi, and the minimum ones varied between -2.7°C at Padeș and 4.7°C at Dr. Tr. Severin.

The last month of the year was characterized by a warm (W) time for the whole study area, according to the Hellmann criterion (Table 1). The average air temperature for the entire Oltenia region was 3.1°C and its deviation from the reference period was 2.9°C, being the fourth largest deviation, since 2019, after November (4.1°C), March (4.0°C) and February (3.2°C). The maximum and minimum values of the air temperature recorded values between 9.8°C at Voineasa, 17.0°C at Polovragi, -10.4°C at Tg. Logrești and -3.4°C at Calafat.

The analysis of the precipitation regime

January 2019 was a very rainy (VR) and excessively rainy (ER) month in most of the study area. The monthly average precipitation in the entire study area was 83.1 mm. In January, the percentage deviation from the precipitation amount for the reference period 1901-1990 was 91.1%, which confirms that, on average, according to the Hellmann criterion, the month was excessively rainy (ER) for the entire study area (Table 2).

Table 2. The matrix of the pluviometric time types recorded in the Southern-Western Development Region of Oltenia, in 2019, after Hellmann Criterion

MS	Months					
	I	II	III	IV	V	VI
Dr. Tr. Severin	ER	VD	ED	ER	N	SR
Calafat	ER	ED	ED	N	ER	VR
Bechet	VD	ED	VD	N	VD	ER
Băilești	VR	ED	ED	N	VD	ER
Caracal	VR	ED	VD	SD	R	ER
Craiova	ER	VD	D	N	D	ER
Slatina	ER	ED	VD	VD	SD	ER
Bâcleș	-	ED	ED	VR	VD	ER
Tg. Logrești	ER	VD	ED	VR	N	ER
Drăgășani	ER	ED	VD	SR	D	ER
Padeș (Apa Neagră)	ER	ED	ED	VR	SD	ER
Tg. Jiu	ER	VD	ED	N	ER	ER
Polovragi	ER	ED	ED	N	R	SR
Rm. Vâlcea	ER	ED	ED	VD	N	ER
Voineasa	-	ED	ED	N	N	ER
Oltenia average	**ER**	**ED**	**ED**	**N**	**N**	**ER**
MS	**Months**					
	VII	**VIII**	**IX**	**X**	**XI**	**XII**
Dr. Tr. Severin	SD	ED	ED	ED	ER	ED
Calafat	VR	ED	ED	ED	ER	ED
Bechet	D	ED	ED	ED	ER	ED
Băilești	VR	ED	ED	ED	R	ED
Caracal	SD	ED	ED	ED	ER	ED
Craiova	R	ED	ED	D	ER	ED
Slatina	N	ED	ED	VD	VR	VD
Bâcleș	ER	ED	ED	ED	VR	ED
Tg. Logrești	D	ED	ED	VD	ER	D
Drăgășani	N	ED	ED	VD	ER	N
Padeș (Apa Neagră)	VD	ED	ED	ED	ER	D
Tg. Jiu	VD	N	ED	ED	ER	VD
Polovragi	ED	VD	ED	D	R	VD
Rm. Vâlcea	VD	VD	VD	SD	VR	VD
Voineasa	VD	R	ED	ED	N	ED
Oltenia average	**D**	**VD**	**ED**	**ED**	**ER**	**VD**

ED – excessively droughty; VD – very droughty; D – droughty; SD – slightly dry; N – normal; SR – slightly rainy; R – rainy; VR – very rainy; ER – excessively rainy.

Source: NMA archive for temperature and precipitation values.

February was an excessively (ED) droughty month in most of the study area (Table 2). The monthly average precipitation for the entire region was 16.9 mm, and according to Hellmann criterion, it was an excessively droughty month (Table 2).

The excessively droughty (ED) weather continued through March, with a monthly average precipitation of 15.1 mm for Oltenia. (Table 2).

The monthly interval February – March is part of the period of formation of water reserves in the soil for the field crops [2]. This interval for the year 2019, at the level of the Oltenia region is characterized by a deficient precipitation regime.

April has a monthly average precipitation of 62.6 mm for the whole area, being, according to the Hellmann criterion, a normal pluviometric month. In the spatial distribution of the precipitation amounts, it was found that at Dr. Tr. Severin MS, the month was excessively rainy (ER), very rainy (VR) at Bâcleș, Tg. Logrești and Padeș meteorological stations, slightly dry (SD) at Caracal, very droughty (VD) at Slatina and Rm. Vâlcea and at the rest of the meteorological stations, the month was normal pluviometric (Table 2).

May continued to be normal pluviometric throughout the study area, with a monthly average precipitation of 80.6 mm. In the spatial distribution of the precipitation amounts, there were identified areas from excessively rainy (Calafat and Tg. Jiu) to very droughty areas (Bechet, Băilești and Bâcleș) (Table 2). On the general background, of normal thermic and rainy weather, according to the Hellmann criterion, Oltenia region is characterized by a uniformity and good and medium vigor of maize plants [1].

June was the rainiest month of the year 2019, with monthly precipitation averaging from 80.4 mm at Dr. Tr. Severin (slightly rainy) to 240.6 mm at Caracal (excessively rainy). In the Oltenia region, the monthly average precipitation was 156.1 mm, with a deviation from the reference period (1901-1990) of 85.4%, thus, being an excessively rainy month, according to Hellmann criterion (Table 2).

July is characterized by the predominance of a deficient precipitation weather (SD, D, VD, ED) at most of the analyzed meteorological stations. The study area is characterized by a monthly average amount of 50.3 mm, thus, being a droughty (D) month, according to Hellmann criterion (Table 2). As a result, drought begins in the second half of summer and the first part of autumn 2019. August was a very droughty (VD) month for the entire study area, with a monthly average precipitation of 28.3 mm. (Table 2).

July and August are considered to be the critical period for maize, both for temperature and precipitation regimes [10]. They were characterized by a normal thermic weather, warm and precipitation deficit at the level of Oltenia region.

In September, the precipitation deficit continues, so that the month was, on average, excessively droughty (ED) for the whole of Oltenia, the amount of precipitation recorded being 11.8 mm. Excessively droughty (ED) weather also characterizes October. The monthly average precipitation is 28.9 mm, for the study area (Table 2).

November is an excessively rainy (ER) month for most meteorological stations, so in Oltenia region there is an excess of precipitation (Table 2). In December 2019, the precipitation deficit is reinstated, the monthly average amount recorded for the entire study area being 26.8 mm. According to Hellmann criterion, December is a very droughty month (Table 2).

The yields of the maize crop are ensured by the distribution of the monthly amounts of precipitation during the vegetation period of the plants and not by the annual amount of precipitation [4].

Taking into account these variations in temperature and precipitation, from one month to another, in which the air temperatures were higher than usual and associated with water deficit from precipitation, especially in the critical period July-August, the vegetation rhythms for the maize crop were forced. As a result, the vegetation has deteriorated due to the drying of the leaves and the undersizing of the fruit elements. These aspects are reflected in the data of the cultivated areas, yields and the average yields per hectare (ha) obtained in the Southern-Western Development Region of Oltenia, in 2019 and shown in Table 3 [11].

Table 3. The cultivated area and the agricultural production of maize in the Southern-Western Development Region of Oltenia (2018-2020)

Culture	Year	Surface (ha)	Production (tone)	Average of production (kg/ha)
maize	2018	321,221	2,362,330	7,354
	2019	337,175	1,924,121	**5,707**
	2020	342,139	1,572,481	4,596

Source: processed data from NIS, 2022.

On a larger cultivated area in 2019, compared to 2018, the average production per hectare was lower by 1,647 kg / ha, due to the influence of the characteristics of the temperature and precipitation conditions of the analyzed year (Table 3).

The average production per hectare of 2018 is considered a record for the maize production for the period 2000-2020 [11].

CONCLUSIONS

The climatic variability, from the point of view of the air temperature and precipitation regime, in the Southern-Wester Development Region of Oltenia was high. The year 2019, at the level of the entire region, was a warm year as a whole. From temperature point of view, the main climatic alternation was between warm and normal thermic weather. In terms of precipitation, the year 2019, at regional level was, on average, normal pluviometric. But, there were large variations in the monthly precipitation, with precipitation deficit, prevailing over long periods of time. The main alternation of the types of precipitation time was between the deficit precipitation time and the excess time.

Depending on the variation of the thermic and precipitation resources and the non-fulfillment of the optimal requirements of the air temperature and precipitation amounts in the critical period July-August, the maize yields of the year 2019 decreased, compared to those recorded in the year 2018.

Author contributions: All authors have equal contribution to the preparation of this scientific paper.

REFERENCES

[1]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2020. Raportul anual 2019. (2019 Annual Report), https://www.meteoromania.ro/despre-noi/raport-anual/raport-anual-2019/, Accessed on March 4th, 2022.

[2]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2021. Raportul anual 2020. (2020 Annual Report), https://www.meteoromania.ro/despre-noi/raport-anual/raport-anual-2020/, Accessed on March 4th 2022.

[3]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2022. 2021 – continua tendința de creștere a temperaturii aerului în România. (2021 – continues the trend of increasing air temperature in Romania), http://www.meteoromania.ro/, Accessed on March 4th, 2022.

[4]Bîlteanu, Ghe., 2001, Phytotechnics (Fitotehnica), vol. 1, Ceres Publishing House, București, 501 p.

[5]Constantin (Oprea), D.M., Marinică, A.F., Marinică, I., Zaharia, L., Grigore, E., Ioana-Toroimac, G., 2018, Les mois d'août de 2000 à 2017: records termiques et pluviométriques dans le sud-ouest de la Roumanie. Actes du 31ème Colloque de l'Association Internationale de Climatologie, 207-212.

[6]Constantin (Oprea), D.M., Marinică, A.F., Marinică, I., Zaharia, L., Grigore, E., Onțel I., Ioana-Toroimac, G., Tișcovschi, A.A., 2019, The thermal and pluvial features of the agricultural year 2018 in the south-western Romania and the effects on the crops. Actes du 32ème Colloque de l'Association Internationale de Climatologie, 543-548.

[7]Constantin (Oprea), D. M., Marinică, I., Ionac, N., Marinică, F.A., Grigore, E., Bogan, E., Tatu, F., 2020, The climate variability of the agricultural year 2016-2017. Case study: The South-West Oltenia Region, Romania. Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development", Vol. 20(3):169-178.

[8]Copernicus: 2019 was the second warmest year and the last five years were the warmest on record. https://climate.copernicus.eu/copernicus-2019-was-second-warmest-year-and-last-five-years-were-warmest-record, Accessed on March 5th, 2022.

[9]Mateescu, E., Tanislav, N., Vătămanu, V.V., 2004. The impact of droght conditions in the Caracal Plain on wheat and maize crops (Impactul condițiilor de secetă din Câmpia Caracalului asupra culturilor de grâu și porumb), Sitech Publishing House, Craiova, 163 p.

[10]Sandu, I., Mateescu, Elena, Vătămanu, V.V., 2010, Climate changes in Romania and their effects on agriculture (Schimbări climatice în România şi efectele asupra agriculturii). Sitech Publishing House, Craiova, 406 p.

[11]Vegetal agricultural areas and productions. http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on March 6th, 2022.

[12]WMO confirms 2019 as second hottest year on record. https://public.wmo.int/en/media/press-release/wmo-confirms-2019-second-hottest-year-record, Accessed on March 5th, 2022.