Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 20, Issue 3, 2020
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE CLIMATE VARIABILITY OF THE AGRICULTURAL YEAR 2016-2017 CASE STUDY: THE SOUTH-WEST OLTENIA REGION, ROMANIA

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Abstract

The agro-climatic resources, especially the thermic and precipitation resources of a territory, are the main natural factor influencing the health status of the vegetation and the productivity of a crop. The main objective of this study is to analyze the thermic and precipitation resources of the agricultural year 2016-2017(01.09.2016-31.08.2017), for the South-West Oltenia Region, in relation to the value of the barley and the two-row barley crops. The analysis will be carried out using the climatological data from 15 meteorological stations belonging to the National Meteorological Administration and the production data from the National Statistics Institute. The methods used in the data analysis are logical, spatial and comparative analyzes, operations in GIS environment and climatic indices (spring arrival Index). The 2016-2017 agricultural year, from a thermic point of view, was a warm year, with an annual average of 10.3°C for the entire region. The spring 2017 was excessively early with the average spring arrival index of 464.4°C. In terms of precipitation, throughout the agricultural year 2016-2017, there were six months of excessively droughty. As a whole, the agricultural year was droughty in most of the region, with an average annual rainfall of 587.4 mm. On this climatic fund, in the study area, there was an average production per hectare, for barley and two-row barley crops of 4,438 kg/ha. The variability of the main thermic and water parameters, of each agricultural year, determines the fluctuation of the crops. The analysis of these resources represents the sine qua non conditions for an efficient agricultural management.

Key words**:** *barley, precipitation resources, the South-West Oltenia Region, thermic resources, two-row barley*

INTRODUCTION

In the current context of climate change, the level of the North hemisphere, the year 2017, was the second warmest year in the history of the temperature recordings on Earth [14]. Also, the year 2017 was the warmest in the history of recordings without the influence of the El Nino climate process [10].
In the South –West Oltenia Region, in 2017, the annual average air temperature was 11.6°C, exceeded by 1.3°C the multiannual average of the reference period 1901-1990, being one of the warmest years in the history of the meteorological observations.
The climatic variability has direct consequences on the agricultural crops, so that the analysis of the main agro-climatic resources (thermic and precipitation resources) of a territory is a sine qua non condition in implementing the agricultural management strategies [11; 3].
The South-West Oltenia Region represents 12% of Romania's surface [4] (Fig. 1). The region is part of the temperate-continental climate, with an average temperature of 9.9°C and an average amount of precipitation of 680 mm, for the period 1901-1990 [5].
The main purpose of this study is to analyze the agro-climatic temperature and precipitation resources of the 2016-2017 agricultural year and their impact on the barley and two-row barley crops in the South-Western Romania. Barley and two-row barley are cereals used in the crop rotation in Romania, without having a technology very different from that of the winter wheat [9].

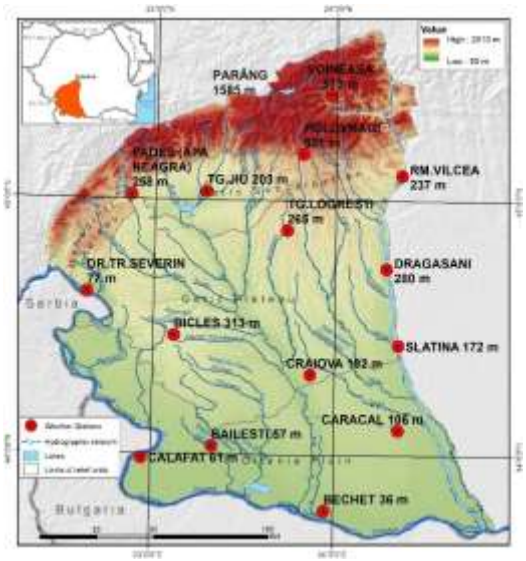

Fig. 1. The location of the study area and of the meteorological stations.
Source: own processing from GIS open sources.

MATERIALS AND METHODS

In the analysis of the thermic and precipitation resources of the agricultural year 2016-2017 (01.09.2016-31.08.2017), for the South-West Oltenia Region, there were used the meteorological-climatic data from 15 meteorological stations (MS) belonging to the National Meteorological Administration (NMA) (Fig. 1) and the production data from the National Institute of Statistics (NIS).
The methods used in data analysis are logical, spatial and comparative analysis, operations in GIS environment and climatic indices (Spring Arrival Index).
The statistical analysis and climate criteria were used in determining the types of weather, according to the Hellmann Criterion [6].

RESULTS AND DISCUSSIONS

The analysis of the thermic and precipitation resources of the autumn 2016

The average temperature for the autumn season, in the South-West Oltenia Region, varied between 9.5°C at Padeș and 12.3°C at Dr. Tr. Severin (Table 1). The deviations of these values from the climatological normal, calculated for the period 1901-1990, varied between -0.8°C at Padeș and 0.5°C at Voineasa, an aspect that is reflected in the predominance of the normal thermic time (N) in the study area and cool time (CO) at Padeș, Polovragi and Tg. Logrești. For the entire study area, the average seasonal temperature was 10.7°C, with a deviation from the period 1901-1990 of -0.2°C, which determined that the autumn 2016 to be thermally normal (N) in the South-West Oltenia Region.
At the level of the autumn months, September registered values between 13.8°C at Voineasa and 20.0°C at Dr. Tr. Severin, so that the month, in most of the study area, was a slightly warm month (SW). The extreme temperatures of the month registered values between 33.6°C at Dr. Tr. Severin and 28.8°C at Voineasa for the maximum temperature, and for the minimum temperature the recorded values were between 6.7°C at Dr. Tr. Severin and 0.7°C at Padeș. As a result, there is an extension of the summer season over the first month of autumn. The ground surface temperature registered, in September, values between 40.4°C at Băilești and 55.6°C at Rm. Vâlcea for the maximum temperature, and values of 1.1°C at Tg. Lotrești and 7.1°C at Caracal for the minimum temperature.
The second month of autumn, October, recorded averages of air temperature that varied between 10.9°C at Dr. Tr. Severin and 7.1°C at Voineasa, with deviations from the period 1901–1990, by -0.1 °C at Voineasa and -2.4°C at Polovragi. According to the Hellmann Criterion, October was cool (CO) and cold (CL) for most parts of the study area, at Drăgășani and Polovragi and normal in the areas: Bechet, Băilești and Voineasa. The monthly maximum air temperature was between 23.2°C at Voineasa and 28.2°C at Bechet. The monthly minimum air temperatures were between -5.1°C at Padeș and 1.4°C at Dr. Tr. Severin. At the ground surface, the temperature of the monthly maximums has recorded values between 28.9°C at Bechet 43.4°C at Craiova, and the monthly minimums have ranged from -4.5°C at Polovragi to 1.7°C at Bechet.
In the last month of autumn, November, there were recorded air temperature values between 6.1°C at Dr. Tr. Severin and 2.1°C at Voineasa, with deviations from the period 1901–1990 between 0.0°C at Caracal and -

1.3°C at Polovragi. In most of the South-West Oltenia Region, November was a normal thermic month (N) according to the Hellmann Criterion. The maximum air temperature recorded values between 15.8°C at Polovragi and 18.5°C at Dr. Tr. Severin and the minimum values have fluctuated between -13.0°C at Calafat to -3.7°C at Caracal. At the ground surface, the maximum temperatures were between 17.2°C at Bechet and 23.8°C at Calafat, and the monthly minimums recorded values of -20.0°C at Calafat and -0.1°C at Bechet. As a result, the thermic potential of the autumn 2016 was within normal limits and in combination with the amounts of excess precipitation has determined a very good development of the autumn agricultural crops, established by barley and two-row barley.

The seasonal amounts of precipitation were between 174.7 mm at Bâcleș and 234.0 mm at Padeș (Table 1), and after the percentage deviations of this deviation from normal, the autumn was from normally rainy (N) at Tg. Jiu to very rainy (VR) and excessively rainy (ER) on extensive areas of the hills and Oltenia Plain (except for two restrict areas at Dr. Tr. Severin and Voineasa). The monthly amounts of precipitation in September 2016 were between 15.2 mm at Dr. Tr. Severin and 94.0 mm at Drăgășani. The percentage deviations of the precipitation quantities, compared to the norms calculated for the reference period 1901-1990 were between -68.6% at Dr. Tr. Severin and 93.3% at Băilești, and according to the Hellmann Criterion, the classifications of the types of precipitation were from excessively droughty (ED) and very droughty (VD) at Dr. Tr. Severin, Tg. Logrești, Padeș, Tg. Jiu and Voineasa to very rainy (VR) and excessively rainy (ER) at Calafat, Băilești, Bechet, Slatina, Bâcleș and Drăgășani. The monthly average of precipitation for the entire region was 50.9 mm, and its deviation from the normal percentage was 7.6%, which after Hellmann Criterion indicates that, on average, it was normally rainy month. The precipitation started in the first decade of the month between September 6th–September7th, when significant precipitation were recorded for agriculture.

Table 1. The thermic and precipitation regime of autumn 2016

The meteorological station	**Altitude (m)**	**The thermic regime (°C)**			
		NT	**T**	**Δ =T-NT**	**HCr**
Dr. Tr. Severin	77	12.3	12.3	0.0	N
Calafat	66	12.1	11.9	-0.2	N
Bechet	65	11.5	11.3	-0.2	N
Băileşti	56	11.5	11.4	-0.1	N
Caracal	112	11.6	11.9	0.3	N
Craiova	190	11.5	11.3	-0.2	N
Slatina	165	11.6	11.3	-0.3	N
Bâcleș	309	10.8	10.7	-0.1	N
Tg. Logrești	262	10.3	9.6	-0.7	CO
Drăgășani	280	11.6	11.2	-0.4	N
Padeș	250	10.3	9.5	-0.8	CO
Tg. Jiu	210	10.8	10.5	-0.3	N
Polovragi	546	10.2	9.5	-0.7	CO
Rm. Vâlcea	243	10.7	11.0	0.3	N
Voineasa	587	7.2	7.7	0.5	N
Parâng	1585	2.6	-	-	-
Oltenia average	-	10.9	10.7	-0.2	N
The meteorological station	**The precipitation regime (mm)**				
	S	**NS**	**Δ=S-NS**	**Δ%**	**HCr**
Dr. Tr. Severin	147.4	186.3	-38.9	-20.9	D
Calafat	229.3	141.8	87.5	61.7	ER
Bechet	213	134.7	78.3	58.1	ER
Băileşti	224.3	137.9	86.4	62.7	ER
Caracal	138.0	123.4	14.6	11.8	SR
Craiova	165.1	122.1	43.0	35.2	VR
Slatina	172.4	132.2	40.2	30.4	VR
Bâcleș	174.7	144.2	30.5	21.2	R
Tg. Logrești	164.8	135.7	29.1	21.4	R
Drăgășani	226.6	153.2	73.4	47.9	ER
Padeș	234.0	214.3	19.7	9.2	SR
Tg. Jiu	186.9	180.1	6.8	3.8	N
Polovragi	244.0	209.0	35.0	16.7	SR
Rm. Vâlcea	189.6	156.8	32.8	20.9	R
Voineasa	63.1	164.5	-101.4	-61.6	ED
Parâng	281.3	197.9	83.4	42.1	VR
Oltenia average	190.9	187.1	3.8	2.0	N

NT – the normal values of the autumn seasonal average temperatures (calculated over the period 1901-1990) (°C); T – the average values of the temperature of the autumn (°C); Δ = T-NT, the deviations from normal (°C); S – the sum of the precipitation in autumn (mm); NS – the normal values of the autumn precipitation (mm); Δ = S-NS, the deviations from normal (mm); Δ% – the percentage deviations from normal; HCr – the Hellmann Criterion.
Source: processed data from NMA, 2020.

In October 2016, the monthly precipitation amounts ranged from 49.5 mm at Caracal to 110.4 mm at Polovragi and the percentage deviations were positive in most of Oltenia and were placed between -60.4 % at Voineasa and 126.3% at Bechet, and according to the Hellmann Criterion, it was a very rainy month (VR) and excessively rainy (ER) in most of Oltenia.

Significant quantities were recorded for agriculture on October 7th, 10th–12th, 16th, 21st–22nd and October 26th. The monthly average quantity for the entire region was 75.3 mm, and the percent deviation to normal was -0.1%, which shows that October 2016 has been normal rainy (N).

In November 2016, the monthly precipitation amounts were between 34.7 mm at Caracal and 92.5 mm at Padeș, and their percentage deviations from normal were between -28.5% at Caracal and 54.6 % at Calafat, determining according to the Hellmann Criterion, classifications of the precipitation time types from normal (N) at Slatina, Padeș, Tg. Jiu Polovragi and Rm. Vâlcea to very rainy (VR) and the exceptionally rainy (ER) at Calafat, Băilești, Craiova, Tg. Logrești and Parâng. At the level of the South-West Oltenia Region, November recorded an average amount of 69.2 mm and a percentage deviation of 19.0%, thus, being, according to the Hellmann Criterion, a slightly rainy month (SR).

The analysis of the thermic and precipitation resources of the winter 2016-2017

In the winter season, the average temperatures, as shown in Table 2, are negative, except for the meteorological station Dr. Tr. Severin, which recorded the value of 0.3°C. The thermic deviation compared to the period 1901–1990, at the level of the South-West Oltenia Region was -0.2°C, so that the winter was thermally normal (N), according to Hellmann Criterion (Table 2).

The average winter season temperature was -1.4°C, with a deviation from normal of -0.2°C, which confirmed that, on average, the winter 2016–201 7 was normally thermic (N) (Table 2).

In the first month of winter, the average values of the air temperature ranged between 2.2°C at Calafat and -3.5°C at Voineasa. December 2016, according to the Hellmann Criterion, was normal (N) from a thermic point of view, for most of the study area, due to the deviations from the period 1901–1990, which ranged between 1.2°C at Calafat and - 2.3°C at Padeș. In terms of the extreme air temperatures, December recorded a monthly maximum of 15.0°C, and a minimum of -11.1°C at the level of the South-West Oltenia Region.

At the ground level, the maximum monthly temperature recorded an average value of 17.1°C for the entire study region. The minimum monthly average ground surface temperature was -5.3°C for the entire study area, so the soil was thawed for most of December.

Table 2. The thermic and precipitation regime of winter 2016-2017

The meteorological station	Altitude (m)	The thermic regime (°C)			
		NT	T	Δ =T-NT	HCr
Dr. Tr. Severin	77	0.4	0.3	-0.1	N
Calafat	66	-0.1	-0.5	-0.4	N
Bechet	65	-0.6	-1.6	-1.0	CO
Băileşti	56	-0.7	-1.7	-1.0	CO
Caracal	112	-1.2	-1.8	-0.6	CO
Craiova	190	-1.0	-1.4	-0.4	N
Slatina	165	-0.8	-1.5	-0.7	CO
Bâcleș	309	-1.4	-1.3	0.1	N
Tg. Logrești	262	-1.1	-2.0	-0.9	CO
Drăgășani	280	-0.6	-0.6	0.0	N
Padeș	250	-1.0	-2.0	-1.0	CO
Tg. Jiu	210	-1.0	-1.1	-0.1	N
Polovragi	546	-1.5	-1.5	0.0	N
Rm. Vâlcea	243	-0.6	-0.5	0.1	N
Voineasa	587	-3.0	-3.2	-0.2	N
Parâng	1585	-5.1	-	-	-
Oltenia average	-	-1.2	-1.4	-0.2	N
The meteorological station	**The precipitation regime (mm)**				
	S	**NS**	**Δ=S-NS**	**Δ%**	**HCr**
Dr. Tr. Severin	56.8	160.5	-103.7	-64.6	ED
Calafat	67.3	123.9	-56.6	-45.7	ED
Bechet	61.7	104.6	-42.9	-41.0	VD
Băileşti	65.4	121.4	-56.0	-46.1	ED
Caracal	71.8	108.7	-36.9	-33.9	VD
Craiova	69.0	109.7	-40.7	-37.1	VD
Slatina	59.0	117.2	-58.2	-49.7	ED
Bâcleș	-	-	-	-	-
Tg. Logrești	55.2	121.7	-66.5	-54.6	ED
Drăgășani	45.9	114.1	-68.2	-59.8	ED
Padeș	63.8	219.6	-155.8	-70.9	ED
Tg. Jiu	57.0	169.9	-112.9	-66.5	ED
Polovragi	46.6	153.4	-106.8	-69.6	ED
Rm. Vâlcea	40.2	120.1	-79.9	-66.5	ED
Voineasa	-	-	-	-	-
Parâng	83.9	160.0	-76.1	-47.6	ED
Oltenia average	60.3	136.1	-75.8	-55.7	ED

NT – the normal values of the seasonal winter averages temperature (calculated over the period 1901-1990) (°C); T – the average values of the temperature of the winter (°C); Δ = T-NT, deviations of the average temperatures from normal (°C); S – the sum of winter precipitation (mm); NS – the normal values of winter precipitation (mm); Δ = S-NS, the deviations from normal (mm); Δ% – the percentage deviations from normal; HCr – the Hellmann Criterion. Source: processed data from NMA, 2020.

January 2017 was, according to the Hellmann Criterion, a cold month (CL) for most of the study area, due to thermic deviations compared

to the period 1901–1990, which varied between -1.4°C at Polovragi and Rm. Vâlcea and -4.0°C at Băilești. The average monthly temperature recorded a temperature difference between -3.3°C at Dr. Tr. Severin and -6.5°C at Voineasa.
In the South-West Oltenia Region, January recorded a monthly average air temperature of -5.1°C and a deviation from the period 1901–1990 of -2.3°C, which determined that the month is cold (CL), according to the Hellmann Criterion.
Most values of the maximum monthly temperature were recorded on January 2nd and 3rd, being between 5.1°C at Voineasa and 12.5°C at Calafat. January recorded values of the minimum monthly temperature between -15.1°C at Dr. Tr. Severin and -25.4°C at Tg. Logreşti.
In conclusion, January 2017 was a cold winter month for the South-West Oltenia Region, from agro-meteorological point of view.
The second month of winter was characterized by average monthly temperatures between 2.7°C at Dr. Tr. Severin and 0.5°C at Voineasa and deviations, compared to the period 1901–1990, between 2.4°C at Polovragi, Bâcleș and Tg. Jiu and 0.9°C at Bechet and Băilești. For most of the study area, February 2017 was a warm month (W) according to the Hellmann Criterion.
In the winter season, the amounts of the seasonal precipitation varied between 40.2 mm at Rm. Vâlcea and 71.8 mm at Caracal, with percentage deviations from the period 1901–1990 between -33.9% at Caracal and -70.9% at Padeș (Table 2).
After the Hellmann Criterion, the winter 2016–2017 was excessively droughty (ED) in most parts of Oltenia.
The average of the seasonal quantities calculated for the whole region was 60.3 mm with the percentage deviation of -55.7%, which designates, on average, an excessively droughty winter (ED) for the whole region.
In December 2016, the monthly precipitation amounts ranged between 0.0 mm at Dr. Tr. Severin and Bâcleș to 9.5 mm Caracal and their percentage deviations from the normal ranged from -100.0% at Dr. Tr. Severin and Bâcleș to -75.9% at Caracal.
After the Hellmann Criterion, December was an excessively droughty month (ED) in all Oltenia. Snow missed throughout the month.
In January 2017, the monthly precipitation were between 4.7 mm at Polovragi and 49.8 mm at Caracal, and the percentage deviations from normal were between -90.4% at Polovragi and 43.5% at Caracal. After the Hellmann Criterion, January 2017 was excessively droughty (ED) and very droughty (VD) in the most part of Oltenia, except the area Bechet, Băilești and Caracal where it was at slightly rainy (SR) at Băilești, and very rainy (VR) at Caracal. The monthly average quantity for the whole region was 25.6 mm, and its percentage deviation from normal was -41.1%, which confirms that January 2017 was very droughty (VD), on average, for the whole region. Snow persisted due to the negative temperatures, with the maximum thickness included, between 5 cm at Tg. Jiu and 38 cm at Caracal.
In the last month of winter, the precipitations registered monthly quantities between 51.8 mm at Padeș and 0.5 mm at Voineasa, with percentage deviations between 3.6% at Craiova and -98.9% at Voineasa, so that February was a deficient precipitation month for most much of the study area. In a small area, at Craiova, February 2017 was normal, according to the Hellmann Criterion. For the whole South-West Oltenia Region, the monthly amount of precipitation was 26.9 mm, with a percentage deviation of -36.5%, thus, being, according to Hellmann Criterion, a very droughty month (VD).
The snow layer, in February 2017, recorded maximum thicknesses between 2 cm at Dr. Tr. Severin and 18 cm at Caracal.

The analysis of the thermic and precipitation resources of spring 2017

The spring season recorded average air temperature values between 9.0°C at Voineasa and 13.6°C at Dr. Tr. Severin and a regional average of 12.1°C (Table 3). The average seasonal air temperature, for the whole region, registered a deviation of 1.6°C compared to the period 1901-1990, being characterized, according to Hellmann Criterion, a warm spring (W) (Table 3).

In the first month of spring, the air temperature was characterized by monthly averages between 6.3°C at Voineasa and 10.8°C at Dr. Tr. Severin. Compared to the period 1901–1990, the thermic deviations oscillated between 3.6°C at Padeș and 5.2°C at Polovragi and Drăgășani.

As a result, March was warm (W) in most of the region and very warm (VW) at Tg. Jiu and Polovragi. The extreme temperatures of March were between 21.8°C at Polovragi and 25.7°C at Calafat in terms of the maximum monthly temperature and between 0.9°C at Bâcleș and -5.0°C at Voineasa, in terms of the minimum temperature monthly. The maximum monthly temperature at the ground surface oscillated between 29.1°C at Padeș and 47.0°C at Dr. Tr. Severin, and the minimum monthly temperature varied between 0.4°C at Drăgășani and -5.0°C at Tg. Logrești.

April was thermally normal throughout the South-West Oltenia Region, according to the Hellmann Criterion. This aspect resulted from the values of the average monthly temperatures that oscillated between 7.8°C at Voineasa and 12.2°C at Dr. Tr. Severin, with deviations from the period 1901–1990 between 0.3°C at Dr. tr. Severin and -0.8°C at Polovragi.The extreme temperatures of this month registered values between -4.1°C at Voineasa and 1.9°C la Dr. Tr. Severin for the minimum air temperature, and for the maximum air temperature the values varied between 24.4°C at Polovragi and 30.3°C la Bechet. At the ground surface, the monthly maximum temperatures were between 27.7°C at Padeș and 50.4°C at Dr. Tr. Severin.

For April, the minimum temperatures on the ground surface varied between 0.9°C at Slatina, Băilești and Bechet and -4.4°C at Polovragi.

The average temperature of the last month of spring recorded values between 13.0°C at Voineasa and 17.9°C at Dr. Tr. Severin, and its deviations from the period 1901–1990 ranged between 0.3°C at Slatina, Bechet and Băilești and 11.0°C at Rm. Vâlcea. According to the Hellmann Criterion, May 2017 was thermally normal (N) throughout Oltenia. The monthly maximum air temperature has recorded a difference between 25.2°C at Polovragi and 32.2°C at Dr. Tr. Severin, which shows that the temperature reached values specific to summer. The monthly minimum air temperature in May was between 1.4°C at Voineasa and 6.5°C at Rm. Vâlcea. The ground surface monthly maximum temperature fluctuated between 33.2°C at Padeș to 63.4°C at Dr. Tr. Severin and the monthly minimum temperatures ranged from 1.0°C to 6.8°C at Polovragi and Drăgășani.

Table 3. The thermic and precipitation regime of spring 2017

The meteorological station	Altitude (m)	The thermic regime (°C)			
		NT	T	Δ =T-NT	HCr
Dr. Tr. Severin	77	11.6	13.6	2.0	W
Calafat	66	11.6	13.3	1.7	W
Bechet	65	11.6	12.8	1.2	W
Băileşti	56	11.6	12.7	1.1	W
Caracal	112	11.2	12.5	1.3	W
Craiova	190	11.2	12.4	1.2	W
Slatina	165	11.1	12.3	1.2	W
Bâcleș	309	10.1	11.9	1.8	W
Tg. Logreşti	262	9.7	11.3	1.6	W
Drăgăşani	280	10.5	12.4	1.9	W
Padeș	250	9.8	11.1	1.3	W
Tg. Jiu	210	10.5	12.5	2.0	W
Polovragi	546	9.2	10.9	1.7	W
Rm. Vâlcea	243	10.4	12.4	2.0	W
Voineasa	587	7.4	9.0	1.6	W
Parâng	1585	-	-	-	-
Oltenia average	-	10.5	12.1	1.6	W
The meteorological station	**The precipitation regime (mm)**				
	S	**NS**	**Δ=S-NS**	**Δ%**	**HCr**
Dr. Tr. Severin	135.1	186.5	-51.4	-27.6	VD
Calafat	182.5	146.2	36.3	24.8	R
Bechet	148.2	143.5	4.7	3.3	N
Băileşti	117.4	157.8	-40.4	-25.6	D
Caracal	134.3	142.2	-7.9	-5.6	N
Craiova	148.0	135.2	12.8	9.5	SR
Slatina	142.9	149.7	-6.8	-4.5	N
Bâcleș	100.4	172.5	-72.1	-41.8	VD
Tg. Logreşti	213.9	161.2	52.7	32.7	VR
Drăgăşani	205.5	147.2	58.3	39.6	VR
Padeș	192.3	248.8	-56.5	-22.7	D
Tg. Jiu	177.7	193.1	-15.4	-8.0	N
Polovragi	232.3	225.2	7.1	3.2	N
Rm. Vâlcea	264.0	192.6	71.4	37.1	VR
Voineasa	153.3	200.6	-47.3	-23.6	D
Parâng	308.8	254.1	54.7	21.5	R
Oltenia average	185.9	177.4	8.5	4.8	N

NT – the normal values of the spring season temperature averages (calculated over the period 1901-1990) (°C); T – the average spring temperature values (°C); Δ = T-NT, the deviations of average temperatures from normal (°C); S – the sum of spring precipitation (mm); NS – the normal values of spring precipitation (mm); Δ = S-NS, the deviations of precipitation from normal (mm); Δ% – the percentage deviations of precipitation from normal; HCr = the Hellmann Criterion.

Source: processed data from NMA, 2020.

Spring Arrival was excessively early in most of Oltenia with spring arrival indices between

313.9°C at Voineasa and 542.2°C at Dr. Tr. Severin, and the average for the entire region was 464.4°C being a sixth in descending order from 1998-2019. This was due the month March was warm. The Spring Arrival index is calculated for the period February 1st–April 10th, 2015, as the sum of the positive daily average values of the air temperature [7; 2]. The seasonal amounts of precipitation were between 100.4 mm at Bâcleș and 264.0 mm at Rm. Vâlcea, and their percentage deviations from normal were between -41.8% in Bâcleș and 39.6% at Drăgășani (Table 3). According to the Hellmann Criterion, in spring 2017, the types of precipitation time regime were very droughty (VD) at Dr. Tr. Severin and Bâcleș, droughty (D) at Voineasa, Padeș and Băilești, normal (N) at Bechet, Caracal, Slatina, Tg. Jiu and Polovragi, slightly rainy (SR) at Craiova, rainy (R) at Calafat and Parâng and very rainy (VR) at Drăgășani, Rm. Vâlcea and Tg. Logrești (Table 3).

The seasonal amount of precipitation for the entire South-West Oltenia Region was 185.9 mm, with a percentage deviation compared to the period 1901–1990 of 4.8%, which makes the spring 2017 be normal rainfall (N), according to the Hellmann Criterion (Table 3).

The precipitation amounts in March ranged between 6.9 mm at Voineasa and 47.5 mm at Calafat and by percentage deviations, between -84.9% at Polovragi and 24.8% at Calafat, thus, being especially a very droughty (VD) and excessive droughty month (ED). At the level of the study area, the average monthly amount of precipitation was 26.7 mm, with a deviation from the period 1901–1990 of -36.4%, thus, being a very droughty month (VD).

In April 2017, the monthly precipitation amounts were trapped between 34.2 mm at Caracal, and 91.1 mm at Padeș, and their percentage deviations from normal were between -78.0% at Voineasa and 55.6% at Drăgășani. According to the Hellmann Criterion, April was with rainy deficit at Bechet, Băilești, Caracal, Bâcleș, Polovragi and Voineasa and the precipitation surplus was at Dr. Tr. Severin, Calafat, Craiova, Tg Logrești, Drăgășani, Padeș, Rm. Vâlcea and Parâng. The average precipitation for the whole region has been 57.2 mm and its percentage deviation from normal was 1.1%, which shows that April was, on average, a normal precipitation month (N) for all Oltenia. There was only an interval with significant precipitation for agriculture: April 16th–April 19th.

In May 2017, the monthly precipitation amounts were between 38.2 mm at Băilești and 170.0 mm at Rm. Vâlcea, and their percentage deviations from normal were between -45.5% at Băilești and 88% at Drăgășani. According to the Hellmann Criterion, May 2017 was: very droughty (VD) at Dr. Tr. Severin and Bailesti, droughty (D) at Slatina and Padeș, normally rainy (N) at Bechet Craiova, rainy (R) at Tg Jiu, very rainy (VR) at Calafat and Parâng and excessively rainy (ER) at Drăgășani, Polovragi and Slatina. For the study area, May was rainy (R) according to the Hellmann Criterion, with an average monthly precipitation of 95.5 mm and a percentage deviation of 20.5%.

Analysis of the thermic and precipitation resources of summer 2017

In the South-West Oltenia Region, the summer was characterized by average monthly air temperatures between 18.1°C at Voineasa and 25.6°C at Dr. Tr. Severin and deviations, compared to the period 1901–1990, between 3.6°C at Dr. Tr. Severin and 1.6°C at Tg. Logreşti (Table 4).

As a result, summer was warm (W) in most of the study area, according to the Hellmann Criterion (Table 4).

In the South-West Oltenia Region, July was characterized by average monthly air temperature values between 17.9°C at Voineasa and 24.8°C at Dr. Tr. Severin and with deviations between 2.2°C at Băilești and Bechet and 5.2°C at Padeș. For the whole region, the average air temperature was 22.5°C and its deviation from the period 1901–1990 was 3.1°C, so that June was warm (W) according to Hellmann Criterion. The extreme temperatures of June recorded values between 32.5°C at Voineasa and 39.9°C at Calafat for the maximum temperature, and for the minimum temperature, the values varied

between 6.5°C at Padeș and Voineasa and 13.5°C at Dr. Tr. Severin.

At the ground surface, the temperature registered extreme monthly values of 7.6°C at Polovragi and 14.4°C at Calafat for the minimum temperature, and the maximum temperature oscillated between 43.7°C at Drăgășani and 67.3°C at Dr. Tr. Severin.

July has an average monthly temperature of 23.0°C and a deviation of 1.5°C for the South-West Oltenia Region, so the month is slightly warm (SW), according to Hellmann Criterion. Within the study area, the average monthly temperature varied between 17.9°C at Voineasa and 25.8°C at Dr. Tr. Severin. Its deviations from the period 1901–1990 were between 0.7°C at Tg. Logrești and 2.8°C at Dr. Tr. Severin.

The minimum air temperatures in July varied between 8.1°C at Voineasa and 14.4°C at Băilești and Calafat, and the maximum temperatures between 32.5°C at Polovragi and 39.1°C at Caracal.

The minimum temperatures on the ground surface ranged between 9.1°C at Polovragi and 14.9°C at Caracal, and the maximum temperatures between 41.5°C at Drăgășani and 66.6°C at Dr. Tr. Severin.

The last month of summer registered a value of 23.7°C at the level of the study area and a deviation of 2.6°C. The monthly average temperature in August was the highest value of the annual average of the monthly averages in the agricultural year 2016–2017. Within the region, the average air temperature for August recorded values between 18.4°C at Voineasa and 26.1°C at Dr. Tr. Severin and deviations between 1.7°C at Tg. Logrești and 3.9°C at Dr. Tr. Severin. According to the Hellmann Criterion, August was warm (W) for most of the study region.

Across the country, August 2017 is in the first three warmest months in the history of meteorological records [1]. The monthly minimum air temperature for August has recorded values between 3.5°C at Padeș and 11.6°C at Dr. Tr. Severin. The extreme ground surface temperatures recorded values between 4.6°C at Polovragi and 13.6°C at Caracal for the minimum temperature, and for the maximum temperature, the values ranged between 41.7°C at Caracal and 69.0°C at Dr. Tr. Severin.

Table 4. The thermic and precipitation regime of summer 2017

The meteorological station	Altitude (m)	The thermic regime (°C)			
		NT	T	Δ =T-NT	HCr
Dr. Tr. Severin	77	22.0	25.6	3.6	VW
Calafat	66	22.3	24.8	2.5	W
Bechet	65	22.2	23.9	1.7	SW
Băilești	56	22.1	24.0	1.9	SW
Caracal	112	22.0	24.4	2.4	W
Craiova	190	21.7	24.4	2.7	W
Slatina	165	21.6	23.7	2.1	W
Bâcleș	309	20.4	23.2	2.8	W
Tg. Logrești	262	19.9	21.5	1.6	SW
Drăgășani	280	20.9	23.6	2.7	W
Padeș	250	19.1	22.1	3.0	W
Tg. Jiu	210	20.5	23.4	2.9	W
Polovragi	546	18.9	21.1	2.2	W
Rm. Vâlcea	243	20.2	22.6	2.4	W
Voineasa	587	16.2	18.1	1.9	SW
Parâng	1585	-	-	-	-
Oltenia average	-	20.7	23.1	2.4	W
The meteorological station	**The precipitation regime (mm)**				
	S	**NS**	**Δ=S-NS**	**Δ%**	**HCr**
Dr. Tr. Severin	66.0	160.0	-94.0	-58.8	ED
Calafat	89.2	146.8	-57.6	-39.2	VD
Bechet	153.8	146.8	7.0	4.8	N
Băilești	100.8	e	-49.7	-33.0	VD
Caracal	105.8	167.4	-61.6	-36.8	VD
Craiova	96.6	164.7	-68.1	-41.3	VD
Slatina	148.8	184.9	-36.1	-19.5	D
Bâcleș	120.9	152.5	-31.6	-20.7	D
Tg. Logrești	158.2	165.4	-7.2	-4.4	N
Drăgășani	149.0	185.6	-36.6	-19.7	D
Padeș	104.8	232.0	-127.2	-54.8	ED
Tg. Jiu	158.2	219.2	-61.0	-27.8	VD
Polovragi	265.2	277.7	-12.5	-4.5	N
Rm. Vâlcea	293.6	254.3	39.3	15.5	SR
Voineasa	352.3	268.1	84.2	31.4	VR
Parâng	246.0	346.8	-100.8	-29.1	VD
Oltenia average	163.1	201.5	-38.4	-19.1	D

NT – the normal values of the seasonal averages of summer temperature (calculated over the period 1901-1990) (°C); T – the average of the temperature of the summer (°C); Δ = T-NT, the deviations from normal (°C); S – the sum of summer precipitation (mm); NS – the normal values of summer precipitation (mm); Δ = S-NS, the deviations from normal (mm); Δ% – the percentage deviations from normal; HCr = the Hellmann Criterion.
Source: processed data from NMA, 2020.

August, in terms of the precipitation resources, was characterized by values between 5.0 mm at Caracal and 110.3 mm at Voineasa, with deviations from the period 1901–1990 between 51.5% at Voineasa and -88.5% at Tg. Jiu. According to the Hellmann Criterion, only on a small area, at Voineasa,

the month was excessively rainy (ER), otherwise the month was excessively droughty (ED).

At the level of the South-West Oltenia Region, for August, the average monthly amount of precipitation registered the value of 38.1 mm, with a percentage deviation of -27.2%, thus, being on average, a droughty month (D).

For the summer of the agricultural year 2016-2017, at the level of the South-West Oltenia Region, the seasonal amount of precipitation was 163.1 mm, with a percentage deviation from the normal of -19.1%, thus, being a droughty summer (D) according to the Hellmann Criterion (Table 4).

The summer drought has affected the water sources not only in the southwestern part of Romania, but even in European continent [8].

The thermic and precipitation resources which are outside the optimum need of growing barley and two-row barley are considered stress factors [12].

In this climatic context of the agricultural year 2016-2017, the average production of barley and two-row barley was 4.438 kg/ha, according to Table 5 [13]. As a result, barley and two-row barley crops are better suited to a thermic context with higher values and lower amounts of precipitation compared to wheat, rye and oat [9].

Table 5. The cultivated area and the agricultural production of barley and two-row barley in the South-West Oltenia Region

Culture	Year	Surface (ha)	Production (tone)	Average of production (kg/ha)
Barley & two-row barley	2016	51,679	183,135	3,544
	2017	48,355	214,617	**4,438**
	2018	49,284	219,507	4,454

Source: processed data from NIS, 2020.

CONCLUSIONS

The agricultural year 2016-2017, at the level of the South-West Oltenia Region, was characterized by positive monthly average air temperatures for 10 of the months of the year.

The warmest month is August, with an average of 23.7°C, and the coldest month is January with an average of -5.1°C, being the 4th coldest month of January in the period 1961-2019. Autumn and winter were normal and spring and summer were warm.

For the whole agricultural year, the space-time extension of the warm weather was 47.2%, of the normal one of 33.9% and of the cold one of 18.9%.

The overall precipitation regime was deficient at almost all meteorological stations in Oltenia, with an annual average for the entire region of 587.4 mm, which percentage deviation from normal was -13.1%, which according to the Hellmann Criterion, it confirms that the agricultural year 2016–2017 was, on average, a droughty year (D).

There were six months of low rain, of which five were excessively droughty and very droughty (ED and VD), and the rainiest month was July. The rainy autumn 2016 and July 2017 are the periods that mainly contributed to the agricultural production of this agricultural year.

The space-time extension of the precipitation excess time was of 36.3%, of the normal rain of 12.1% and of the rain deficient of 51.6 %.

The thermic-precipitation conditions from the region of South-West Oltenia, for the agricultural year 2016-2017, reflect a greater resistance of barley and two-row barley crops to warm and droughty weather, compared to other cereals.

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