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AGRICULTURAL PRODUCTION IN THE NIŠ VALLEY – AGROCLIMATIC CONDITIONS

Nataša Martić Bursać[1*], Radomir Ivanović[2], Milena Nikolić[1]

[1]University of Niš, Faculty of Science and Mathematics,
Department of Geography, Niš
[2]University of Priština temporarily seated in Kosovska Mitrovica
Faculty of Science and Mathematics, Department of Geography,
Kosovska Mitrovica
[*]*natasam@pmf.ni.ac.rs*

Abstract

Agricultural production as the primary economic activity depends on a number of natural and social factors. One of the natural factors that significantly affects the cultivation and production of crops is climate. This paper examines the agroclimatic conditions of the Niš Valley, as an essential prerequisite for the selection of economically viable crops. For the purpose of the analysis, the data on the precipitation and air temperature from the meteorological station Niš from 1951 to 2010 were used. The data were used to determine the detailed agroclimatic indicators and to define the vegetative season for different temperature thresholds and thereby establish better conditions for agricultural production of certain crops. The analysis in the paper is divided for two thirty-year periods (1951-1980 and 1981-2010) in order to determine the trend of climatic changes and thus contribute to the planning and improvement of agricultural production.

Key words: agricultural production, agroclimatic indicators, vegetative season, crops, the Niš Valley.

ПОЉОПРИВРЕДНА ПРОИЗВОДЊА У НИШКОЈ КОТЛИНИ – АГРОКЛИМАТСКИ УСЛОВИ

Апстракт

Пољопривредна производња као примарна привредна делатност зависи од бројних природних и друштвених фактора. Један од природних фактора који значајно утиче на гајење и производњу биљних култура је клима. У раду су испитивани агроклиматски услови Нишке котлине, као битан предуслов за одабир економски исплативих култура. За овакву анализу су коришћени подаци о падавинама и температури ваздуха за период 1951−2010. са метеоролошке станице Ниш. Подаци су послужили да се детаљно утврде агроклиматски показатељи, дефинише вегетациони период за различите температурне прагове

и на тај начин утврде услови за квалитетнију пољопривредну производњу одређених култура. Такође је извршена и упоредна анализа два тридесетогодишња периода 1951−1980. и 1981−2010, како би се утврдио тренд климатских промена, и на тај начин утицало на планирање и побољшање услова пољопривредне производње.

Кључне речи: пољопривредна производња, агроклиматски показатељи, вегетациони период, биљне културе, Нишка котлина

INTRODUCTION

A thorough study of climatic and agroclimatic conditions of a territory is a necessary condition for qualitative and quantitative agricultural production. As climate is one of the natural factors that significantly affect plants, it is necessary to examine in detail the prevalent climatic conditions in a particular territory and thus determine the suitability for growing certain crops. In addition to the latitude, altitude, exposure, humidity, and other climatic factors and elements, special attention in agroclimatic studies is given to the temperature and precipitation regime. The temperature thresholds of 0, 5, 10, 15, and 20 °C are very important for the active life of plants. At 0 °C the active life of plants starts or stops, above 5 °C active vegetation of grasses and small grains in the temperate zone begins. Active growing periods of plants from the subtropical zone begin above 10 °C and of those from the tropics above 20 °C (Komljenović, Todorović, 1998).

Situated in the south of Serbia in the composite valley of the Južna Morava, the Niš Valley represents a large and shallow depression of irregular oval shape. It is located between Seličevica and Mali Jastrebac mountains and their branches in the south and west, as well as Svrljiška and Suva Mountain in the east, i.e. on the borderline of fold mountains and Rhodope mountains. Although largely confined by mountains, it is not completely isolated. Gramada is connected to Svrljig valley with a pass, along the Kutinska River to Zaplanje, and over the low SW rim to Dobrič and Toplica (Martinović, 1976, p. 6). It extends to an area of about 620 km^2 (Ršumovic, 1967). The valley relief is divided into two areas. The lowest part is the bottom of the valley, which is extensively used for agricultural production of wheat and vegetables. The second area covers the rim of the valley in the form of low hills, suitable for cultivation of fruit and grape vines (Kostić, Gajić, 1965).

Agricultural production in the Niš Valley could be significantly improved by numerous measures, notably a detailed study of both natural and social factors that affect it. Considerable attention should be given to olericulture, pomiculture, and viticulture. The aim of this paper is to analyze the agroclimatic parameters and conditions in the Niš valley, as one of the natural factors of agricultural production.

MATERIALS AND OPERATING METHODS

For the identification and evaluation of agroclimatic characteristics of Niš valley, we reviewed the data from the meteorological station Niš for the period between 1951 and 2010. We also performed a comparative analysis of two thirty-year periods – 1951-1980 and 1981-2010.

The data on temperature and precipitation were studied in detail and the specific agroclimatic indicators were calculated based on them. They are the best way to define the climate of a territory and advantages for the development of agricultural crops.

Based on the mean monthly data, we also obtained the mean annual and mean perennial temperature value for the given period and the vegetation period. Temperature fluctuations on a monthly basis in the monitored periods were determined. The temperature trend for the 1951-2010 period was established using the Mann-Kendall test. Temperature sum, standard deviation, the coefficient of variation, and mean monthly minimum and maximum temperatures by periods of time are given in tables. The sum of active temperatures, the start and end date of the vegetative season, and temperature sums for temperature thresholds of 5, 10, and 15 °C were also determined. The graphics show the average monthly temperature for the 1951-2010 period with a trend line, and comparative temperature values in the 1951-1980 and 1981-2010 periods.

We calculated the mean annual and mean perennial rainfall for a given period and the vegetative period. We established the trend of rainfall using the Mann-Kendall test for the 1951-2010 period. Rainfall sum, standard deviation, and the coefficient of variation for periods of time are given in tables. We used a graphic presentation to show the average annual precipitation sum with the trend of 1951-2010, followed by a comparative graph of monthly precipitation sum for the 1951-1980 and 1981-2010 periods.

Climate aridity of the Niš valley is determined by calculation of Lang's rain factor (KFg) on the annual level and Gračanin's rain factor (KFm) for each month of the year; we also used De Marton's drought index (Is) calculated on an annual and monthly basis as well as Lobova's index of aridity (Va) calculated for the vegetative season. All calculated values are given in tables.

In order to determine the conditional balance of humidity, which characterizes the humidity of a territory, we calculated the hydrothermal coefficient (Ks) according to Seljaninov. To calculate this ratio, it is necessary to determine the days of the beginning and end of the vegetative season, as well as its duration and temperature sums by temperature thresholds. These values are given in tables.

To graphically show the climate of a place, climate diagrams are used, which best represent humidity and aridity by month. The paper uses the climate diagram according to Walter and Lieth.

TEMPERATURE AND PRECIPITATION REGIME OF THE NIŠ VALLEY

For the planning of certain agro operations, such as tillage, fertilization, irrigation, drainage, planting, etc., it is necessary to know the climate and its fluctuations over a longer period of time. Heat is one of the main environmental factors that influence growth and development of plants throughout the vegetative season, from germination and growth to the formation and maturation of the fruit. In addition to heat, precipitation is necessary for life and productivity of plants (Otorepec, 1991, p. 21, 28).

For successful crop production it is first necessary to define the climate of a territory on the basis of air temperature and precipitation. Considering only mean annual air temperature, Gračanin performed climate classification (Gračanin, Ilijanić, 1977; Komljenović, Kondić, 2011a, p.17), according to which the Niš valley is classified as having a moderately warm climate (8-12 °C), and for the 1951-2010 period, mean annual air temperature has a value of 11.76 °C. The graph shows mean annual air temperature for Niš in the monitored period (Graph 1). Additionally, annual rainfall was independently analyzed and climatic classification was performed according to Azzi (Azzi , 1952), on the basis of which it was determined that the Niš valley (1951-2010) has a sub-humid (semi-humid, 500-1000 mm) climate, because of the annual rainfall sum of 592.21 mm. However, none of these classifications provide a true picture of the climatic conditions of a territory; therefore, most commonly used classifications include precipitation and temperature and their interdependence in their analyses.

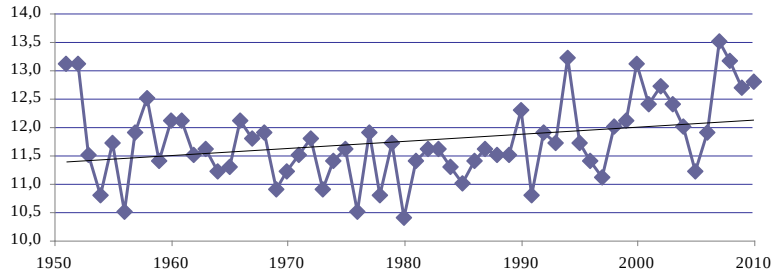
A comparative analysis of average monthly and annual values of air temperature for Niš over two thirty-year periods – 1951-1980 and 1981-2010 – showed a rise in temperature in the latter period, both annual and monthly (Table 1, Graph 2). All the months show higher values of air temperature in the second thirty-year period of observation, with the exception of November and December, which show lower values. In both observed periods, the variation coefficient is the same and amounts to 0.06. The increase in mean annual temperature and the same coefficient of variation imply that the dissipation of temperature around the mean value (standard deviation) increased in the second period.

Thermal fluctuations during the year are very important for agriculture, especially during the vegetative season, due to adverse effects of extremely low and extremely high temperatures. Maximum and minimum mean monthly temperatures for Niš are given in Table 2. Determining these values is essential, as the biological minimum temperature is not the same for different crops or for individual stages of development. Stepanov states that wheat, barley, and oats sprout at 4-5 °C, flower at 10-12 °C, while the fruit bearing stage is at 12-10 °C. Peas and horse bean sprout at 4-6 °C , flower at 8-10 °C, and bear fruit at 12-10 °C, while beans sprout at 12-13 °C , flower at 15-18 °C and bear fruit at 15-12 °C, etc. (Šušić, 2000, p. 29). In case of

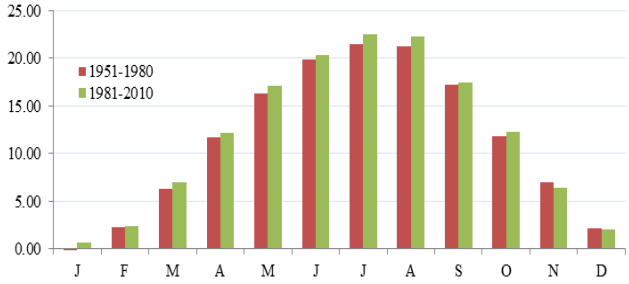
extreme temperatures in these stages of growing, one can expect poor yield. The average monthly temperature fluctuation in the Niš valley in the vegetative season, from April to October, has a value of 19.9 °C. The lowest mean monthly air temperature is in April, 6.4 °C, and the highest in August, 26.3 °C.

Table 1. Mean monthly and annual air temperature (μ), temperature sum, standard deviation (σ), coefficient of variation (CV), mean minimum and maximum temperature in Niš by periods

Period		J	F	M	A	M	J	J	A	S	O	N	D	Av Ann.	Year Sum
1951-1980	μ	0.00	2.32	6.30	11.68	16.35	19.90	21.47	21.31	17.28	11.86	7.04	2.16	11.56	4205.25
	σ	2.35	3.31	2.15	1.59	1.56	1.26	1.32	1.79	1.83	1.78	1.96	2.16	0.67	251.74
	Cv	-	1.43	0.34	0.14	0.10	0.06	0.06	0.08	0.11	0.15	0.28	1.00	0.06	0.06
	min	-5.00	-6.10	1.90	7.90	13.70	17.70	19.20	17.30	13.30	8.60	2.40	-1.50	10.40	-
	max	3.70	7.60	9.80	14.70	19.70	22.10	24.80	26.30	20.40	16.40	9.80	6.40	13.10	-
1981-2010	μ	0.62	2.38	7.03	12.18	17.13	20.38	22.49	22.32	17.44	12.33	6.39	2.08	11.96	4362.85
	σ	2.19	2.69	2.33	1.86	1.51	1.47	1.42	1.64	1.57	1.48	2.60	2.10	0.72	262.85
	Cv	3.54	1.13	0.33	0.15	0.09	0.07	0.06	0.07	0.09	0.12	0.41	1.01	0.06	0.06
	min	-3.70	-3.70	1.80	6.40	12.70	17.40	19.40	19.60	14.50	8.80	-0.20	-2.80	10.80	-
	max	5.40	7.30	11.60	15.00	20.20	23.60	26.20	25.60	21.70	14.70	12.10	4.90	13.50	-
1951-2010	μ	0.31	2.35	6.67	11.93	16.74	20.14	21.98	21.82	17.36	12.09	6.72	2.12	11.76	4284.05
	σ	2.28	2.99	2.25	1.73	1.57	1.38	1.45	1.77	1.69	1.64	2.31	2.11	0.72	260.44
	Cv	7.38	1.27	0.34	0.15	0.09	0.07	0.07	0.08	0.10	0.14	0.34	1.00	0.06	0.06
	min	-5.00	-6.10	1.80	6.40	12.70	17.40	19.20	17.30	13.30	8.60	-0.20	-2.80	10.40	-
	max	5.40	7.60	11.60	15.00	20.20	23.60	26.20	26.30	21.70	16.40	12.10	6.40	13.50	-



Graph 1. Average annual air temperature with a trend line for Niš in the 1951-2010 period

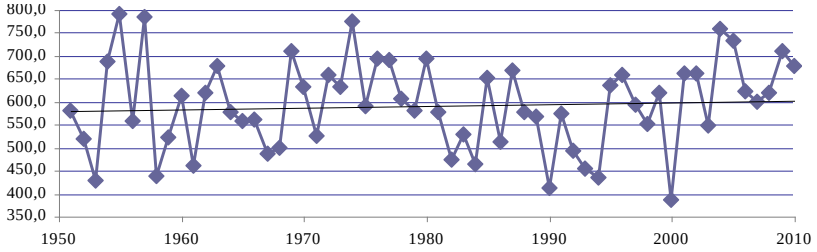


Graph 2. Comparative values of mean monthly air temperatures for Niš during the 1951-1980 and 1981-2010 periods

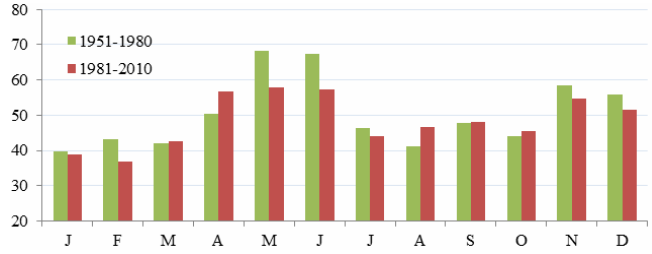
After the analysis of the sum of precipitation on a monthly and annual basis for Niš in the 1951-2010 period (Graph 3) and the comparative analysis of two thirty-year periods (1951-1980 and 1981-2010) (Table 2, Graph 4), a significant reduction in the amount of annual rainfall by 23.84 mm was observed in the second period. The standard deviation of rainfall is slightly lower in the second period, while the coefficient of variation increased, as a result of a significant reduction in the amount of precipitation. On the monthly level, precipitation in the vegetative season showed a slight increase in April, August, September, and October, while in May, June, and July there was a significant decrease in the amount of rainfall in the second thirty-year period. May and June have the highest and July and August have the lowest rainfall in the vegetative season. In these months, there is considerable variation of precipitation in both periods.

Table 2. Mean monthly and annual sums (Σ), standard deviation (σ) and variation coefficient (CV) of precipitation in Niš by periods

Period		J	F	M	A	M	J	J	A	S	O	N	D	Annual
1951	Σ	39.78	43.10	41.95	50.37	68.14	67.25	46.23	41.03	47.91	44.16	58.45	55.77	604.13
-	σ	20.15	22.60	25.53	22.81	37.53	35.31	29.03	31.11	38.04	31.19	30.70	28.37	98.35
1980	Cv	0.51	0.52	0.61	0.45	0.55	0.53	0.63	0.76	0.79	0.71	0.53	0.51	0.16
1981	Σ	38.77	36.77	42.48	56.65	58.02	57.31	43.96	46.66	47.95	45.50	54.75	51.46	580.29
-	σ	24.48	20.82	22.39	25.09	24.79	33.73	35.66	30.72	40.93	34.63	38.75	28.19	95.91
2010	Cv	0.63	0.57	0.53	0.44	0.43	0.59	0.81	0.66	0.85	0.76	0.71	0.55	0.17
1951	Σ	39.27	39.94	42.21	53.51	63.08	62.28	45.10	43.85	47.93	44.83	56.60	53.62	592.21
-	σ	22.23	21.78	23.81	23.98	31.94	34.60	32.26	30.79	39.17	32.68	34.71	28.13	97.06
2010	Cv	0.57	0.55	0.56	0.45	0.51	0.56	0.72	0.70	0.82	0.73	0.61	0.52	0.16



Graph 3. The sum of annual precipitation with a trend line for Niš in the 1951-2010 period



Graph 4. Comparative values of monthly precipitation sum for Niš in the 1951-1980 and 1981-2010 periods

Air temperature trends for the 1951-2010 period according to Salmi, Maatta, Anttila, Ruoho/Airola, Amnell (2002) show a positive trend at the level of significance of $\alpha = 0.05$. In the first half of the 1951-2010 period the trend is slightly negative, with the significance level $\alpha = 0.05$, while in the second half of the 1951-2010 period the trend is very positive with the level of significance of $\alpha = 0.001$, i.e. it has a very high level of reliability – 99.9%. Using the Mann-Kendall test, the precipitation trend was established and it was determined that there is no significant trend in the 1951-2010 period. In the first half of the observed period there is no significant trend, while in the second half there is a significant slightly positive trend with the reliability level of 95 %.

AGROCLIMATIC INDICATORS

Agroclimatic conditions determine the structure of production, yield, fruit quality, and economic profitability of any crops. Therefore, the analysis of agroclimatic conditions is the basis for the planning of agricultural production (Šušić, 2000b, p. 23).

The obtained value of Lang's rain factor for Niš (1951-2010) is 50.4 at the annual level (Table 3). Thus, the Niš Valley according to Lang's classification has humid climate and belongs to steppes and savannas (Milosavljević, 1990, p. 242). The Lang's rain factor was discussed over two thirty-year periods 1951-1980, 1981-2010. The obtained values are 52.28 for the first period and 48.50 for the second period. These values of the rain factor favor the given claims that the Niš Valley has a humid climate, which, according to Lang's classification belongs to the steppes and savannas with values between 40 and 60. A negative trend of rain factor values is noted.

Table 3. Rain factor by Lang and Gračanin for Niš by periods

	Gračanin's rain factor												Lang's rain factor
Period	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1951-1980	-	18.55	6.66	4.31	4.17	3.38	2.15	1.93	2.77	3.72	8.30	25.78	52.28
1981-2010	62.53	15.43	6.04	4.65	3.39	2.81	1.95	2.09	2.75	3.69	8.56	24.74	48.50
1951-2010	127.37	16.97	6.33	4.48	3.77	3.09	2.05	2.01	2.76	3.71	8.42	25.27	50.36

Rain factor on a monthly level is calculated using Gračanin's method (Table 3) (Ducić, Anđelković, 2004, p. 147). On the observation period (1951-2010), perihumid climate is typical for the months of January, February and December with the rain factors of 127.4; 17 and 25.3, respectively. Humid climate is characteristic for the month of November with the rain factor of 8.4. Semihumid climate is typical for the month of March with the rain factor of 6.3. Semi-arid climate is during April, May and October with the rain factor of 4.5; 3.8; 3,7. Arid

climate is during June, July, August and September with the rain factor of 3.1; 2.1; 2.0, 2.8.

Gračanin's rain factor is calculated over a thirty-year period. Based on the above, it can be concluded that the Niš Valley has extremely dry summer months, with prolonged periods of aridity in the month of September. Extremely humid climate is characteristic for the winter months, from December to February. Only in the transitional seasons are there small variations in the rain factor on a monthly level, so the month of March in the 1951-1980 period has a value of 6.66, which is the transition between the humid and the semi-humid climate. By comparing the value of the rain factor between these two periods, we see the decline in the value of the rain factor in the second thirty-year period in all months except April and August.

Table 4. De Marton's drought index for Niš by periods

	Gračanin's rain factor												Lang's rain factor
Period	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1951-1980	47.75	41.97	30.89	27.88	31.04	26.99	17.63	15.73	21.07	24.24	41.15	55.02	28.03
1981-2010	43.81	35.63	29.93	30.64	25.67	22.64	16.24	17.33	20.97	24.46	40.08	51.12	26.42
1951-2010	45.72	38.79	30.40	29.28	28.31	24.80	16.92	16.54	21.02	24.35	40.62	53.08	27.22

De Marton's drought index (Penzar, 1989) was calculated for Niš (1951-2010) on the annual and monthly level. On the annual level, it is 27.2, which puts the Niš Valley among the areas with exorheic drainage (Table 4). On the monthly level (1951-2010), drought index has the following values: January, November, and December are the months with heavy drainage, 45.7, 40.6, and 53.1, respectively. Constant peripheral drainage occurs in February and March, with the values of 38.8 and 30.4. Exorheic drainage occurs in April, May, June, September, and October with the values of 29.3, 28.3, 24.8, 21.0, and 24.3, respectively. Exorheic or endorheic drainage occurs in July and August with the values of 16.9 and 16.5.

De Marton's drought index is calculated over a thirty year period and the values are given in Table 4. Average annual values of drought index for the two thirty-year periods are 28.03 for the first period and 26.42 for the second period, which confirms that, according to De Marton, the Niš Valley is classified as an area with exorheic drainage. Through a comparative analysis of these values, it can be stated that there is a reduction of the index in the second thirty-year period, which indicates a negative trend of the drought index in the Niš Valley.

Considering the obtained monthly values of the drought index for a thirty year period, we can see minimal differences on a monthly level. We also observed a reduction of monthly drought index values in the second

thirty-year period. Drought index values lower than 10 are not recorded in the observed periods, which excludes the existence of border desert endorheic areas, as well as extremely desert areas in the Niš Valley.

Table 5. Aridity index by Lobova for Niš by periods

Period	Lobova aridity index, Va
1951-1980	0.79
1981-2010	0.73
1951-2010	0.76

The index of aridity by Lobova (Burić, ivanović, Mitrović, 2007, p. 78) was calculated for the observed period (1951-2010), but only in the vegetative season (April-October) (Table 5). Aridity index value of 0.76 indicates that the Niš Valley has an arid climate in the vegetative season. This index is calculated over two thirty-year periods (1951-1980 and 1981-2010), and the obtained values are 0.79 and 0.73, respectively. The aridity index by Lobova shows a slight decline in the value in the second thirty-year period, which confirms the previous statement about climate aridity.

The hydrothermal coefficient (Ks) according to Seljaninov (Otorepec S, 1973; Komljenović, et al., 2011b, page 20.) is an important indicator of the humidity of a territory in the vegetative season, and its special importance stems from the aspect of successful crop production. The Ks is the ratio between the amount of rainfall in a given period and temperature sum for the same period decreased 10 times. This decrease implies the assumption that the use of water for evaporation during summer months is approximately equal to the temperature sum decreased 10 times. According to the degree of humidity, Seljaninov writes about five zones or areas.

Calculation of the hydrothermal coefficient requires prior determination of the beginning and end of the vegetative season for the temperature thresholds of 5 ℃, 10 ℃, and 15 ℃, since not all plants have the same need for warmth. Cryophile plants are adapted to low temperatures, as they originate from temperate areas (small grains, peas, red clover, turnips, onions, lettuce, many grasses, cabbage, spinach, pear, apple, etc.). Thermophile plants are adapted to higher temperatures, as they are from southern areas and do not tolerate frost (corn, cotton, sorghum, millet, peanuts, tomatoes, peppers, beans, melons, watermelons, figs, etc.). Mezophile plants adapted to subtropical regions have moderate demand for heat (Komljenović, 1998b).

The beginning, end, and duration of the vegetative period for temperature thresholds of 5 °C, 10 °C, and 15 °C are given in Table 6. We determined the length of the vegetative period and precipitation and temperature sums of the mentioned thresholds, which are given in Table 6, and then we calculated Seljaninov's hydrothermal coefficient by periods.

Table 6. Length of the vegetative season, temperature sum and precipitation sum during the vegetative season for temperature thresholds of 5 °C, 10 °C, and 15 °C in Niš by periods

Period	Threshold in °C	Beginning of vegetative season	End of vegetative season	Duration of vegetative season in days	Temperature sum in vegetative season in °C	Precipitation sum in vegetative season in mm
1951-1980	5	3 March	27 November	270	4039.16	456.93
	10	4 April	25 October	205	3560.19	351.51
	15	2 May	27 September	149	2880.14	263.57
1981-2010	5	5 March	25 November	266	4151.69	438.67
	10	1 April	28 October	211	3777.16	351.65
	15	1 May	28 September	151	3019.46	250.70
1951-2010	5	4 March	26 November	268	4095.47	447.75
	10	2 April	26 October	208	3673.71	353.34
	15	1 May	28 September	151	2966.61	259.04

Table 7. Hydrothermal coefficient by Seljaninov for the temperature threshold of 10 °C in Niš by periods

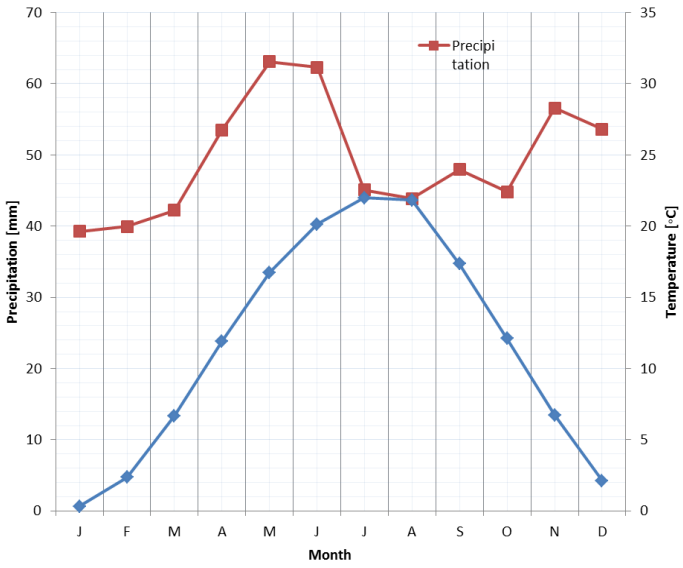
Period	A	M	J	J	A	S	O	Annual
1951-1980	1.44	1.34	1.13	0.69	0.62	0.92	1.20	0.99
1981-2010	1.55	1.09	0.94	0.63	0.67	0.92	1.19	0.93
1951-2010	1.49	1.22	1.03	0.66	0.65	0.92	1.20	0.96

The obtained values of the hydrothermal coefficient according to Seljaninov on the annual level and by observed period are given in Table 7 and are 0.9, 0.93, and 0.96, respectively. This conditional balance of humidity of a territory suggests that the Niš Valley ranks in the third zone (0.7-1) according to Seljaninov, with a clear lack of humidity, where irrigation is justified only for primary crops during the vegetative season. Considering annual values of the Ks in parallel thirty-year periods, it can be concluded that there is a downward trend in the value of the Ks, which implies that humidity is decreasing in the Niš Valley, which may lead to changes in the structure of agricultural crops in the future.

Seljaninov's coefficient is considered for the mentioned periods and by month during the vegetative season for the temperature threshold of 10 °C because most crops in the Niš Valley are biologically active during this season. The obtained values of the hydrothermal coefficient classify months into the following zones according to Seljaninov: the month of April, when the vegetative season starts, has the Ks values of 1.4, 1.55, and 1.49 respectively, and belongs to the area of excessive humidity, i.e. the first zone. The month of May, with the values of 1.34, 1.09, and 1.22, is characterized by sufficient humidity and is classified in the second zone. The month of June, with the Ks values of 1.13, 0.94, and 1.03, has the features of both the second and the third zone, which has a clearly visible lack of humidity. The month of July, with the values of 0.69, 0.63, and 0.66, belongs to the fourth zone according to Seljaninov, which is

characterized as an area of dry land farming and low unreliable yields. Irrigation is required for primary cultures. The month of August, with the Ks values of 0.62, 0.67, and 0.65 also belongs to this zone, while September is classified in the aforementioned third zone with the value of 0.92, which occurred in all three periods of observation. The month of October, after the vegetative season ends, has the Ks value of 1.20, 1.19, and 1.20, which places it in the zone with sufficient humidity, the same as the month of May. Therefore, it can be concluded that the values of the Ks in comparative thirty-year periods also show a decrease in this coefficient in the vegetative season, except in April and August.

Humidity or aridity of a place's climate can be best illustrated through climate diagrams. For this graphical method we used the climate diagram by Walter and Lieth (Komljenović, 2011v, p. 23). For dry (arid) areas, such as the Niš Valley, the ratio of air temperature and precipitation is 1:2. This ratio implies that 10 °C corresponds to 20 mm of rainfall. Based on the values of mean monthly air temperature and monthly precipitation sum, two curves are drawn on the climate diagram (Figure 5). The area above the temperature curve and below the curve of precipitation is the wet part of the year, and the area under the temperature curve and above the precipitation curve represents the dry part of the year. Based on the climate diagrams of Niš in the 1951-2010 period, we observe that the curves touch in July and August, which suggests that these months are on the verge of aridity and that the irrigation of primary cultures is necessary. The previously calculated rain factor, drought index, and hydrothermal coefficient support this claim.



Graph 5. Climate diagram for Niš in the 1951-2010 period

CONCLUSION

The mean annual air temperature for Niš in the observed period is 11.76 °C. This value places the Niš Valley among the areas of warm temperate climates according to Gračanin's classification. A comparative analysis of average annual and monthly temperatures of the thirty-year periods showed a tendency of increase both on the annual and the monthly basis. The lowest mean monthly air temperature in the vegetative period is in April, 6.4 ℃, and the highest in August, 26.3 ℃. Temperature fluctuation of average monthly temperatures is 19.9 ℃. The Mann- Kendell test showed that there is a positive trend at the level of significance of $\alpha = -0.05$.

The annual amount of precipitation in the observed period is 592.21 mm. This value indicates that the Niš Valley has sub-humid (semi-humid) climate according to the classification of climate by Azzi. Through the comparative analysis of two thirty-year periods, we observed a decrease in annual precipitation by 23.84 mm of rainfall in the first observed period, while in the second period, there is a slight upward trend. Months with the highest rainfall in the vegetative season are May and June, and with the lowest July and August, which implies considerable variation of precipitation in both periods.

Through a complete analysis of air temperature and precipitation, it is concluded that there is a tendency of increase in air temperature in the second thirty-year period, while there is a decrease in precipitation in the same period. It should be noted that July and August are months with the lowest rainfall and the highest air temperatures.

The obtained annual value of Lang's rain factor is 50.4. Hence, we can conclude that, according to Lang's classification, the Niš Valley has a humid climate and belongs to the group of steppes and savannas. There was a negative trend in the values of the rain factor.

Gračanin's rain factor was calculated on a monthly basis and a comparative analysis of the two thirty-year periods was performed. Based on all of the above, it can be concluded that the Niš Valley has extremely dry summers, with prolonged periods of aridity over the month of September. Extremely humid climate is present during the winter months from December to February. Only during transitional seasons are there small variations in the rain factor on a monthly basis. There is a noticeable decline in the values of the rain factor in the second thirty-year period in all the months except April and August.

The drought index according to De Marton was calculated on the annual and monthly basis. On the annual basis it is 27.2, which places the Niš Valley among the areas with exorheic drainage. Considering the obtained monthly values of drought index for the thirty-year periods, we noticed minimal differences on a monthly basis. We also observed a reduction of monthly drought index values in the second thirty-year period.

The aridity index according to Lobova was calculated for the observed period, but only in the vegetative period (April-October). The value of the aridity index by Lobova of 0.76 indicates that the Niš Valley has arid climate in the vegetative period. We also observed a slight decrease in the value of the index in the second thirty-year period.

The hydrothermal coefficient by Seljaninov was calculated on the annual level for temperature thresholds of 5 °C, 10 °C, and 15 °C. This conditional balance of humidity of a territory suggests that the Niš Valley ranks in the third zone (0.7-1) according to Seljaninov, with a clear lack of humidity, where irrigation is justified only for primary crops during the vegetative period. Considering the annual values of the Ks in parallel thirty-year periods, it can be concluded that there is a downward trend in the value of the Ks, which indicates that humidity in the Niš Valley is decreasing, which may lead to changes in the structure of agricultural crops in the future.

Climate diagrams showed that July and August are on the verge of aridity and that the irrigation of primary cultures is necessary.

Finally, we conclude that if such climatic trends continue, it will be necessary to introduce certain agricultural measures in order to maintain and improve agricultural production. We can also conclude that it would be desirable for producers to focus on cultures which are more tolerant of high temperatures and lack of humidity in the vegetative season, especially in July and August.

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ПОЉОПРИВРЕДНА ПРОИЗВОДЊА У НИШКОЈ КОТЛИНИ – АГРОКЛИМАТСКИ УСЛОВИ

Наташа Мартић Бурсаћ[1], Радомир Ивановић[2], Милена Николић[1]
[1]Универзитет у Нишу, Природно-математички факултет,
Департман за географију, Ниш
[2]Универзитет у Приштини са привременим седиштем у Косовској Митровици,
Департман за географију, Косовска Митровица

Сажетак

За квалитативну оцену агроклиматских услова Нишке котлине анализирани су подаци о температури ваздуха и падавинама за Ниш у периоду 1951−2010. године. На основу њих утврђени су релевантни параметри који на најбољи начин дефинишу агроклиматске услове и погодности за пољопривредну производњу. Такође је извршена упоредна анализа два тридесетогодишња периода 1951−1980. и 1981−2010. године.

Нишка котлина се сврстава, по Грачаниновој класификацији, у подручја умерено топле климе, јер средња годишња температура ваздуха у опсервационом периоду износи 11,76°C. Упоредна анализа средњих месечних и годишњих температура ваздуха у два тридесетогодишња периода показује тенденцију раста. Мен Кенделовим тестом је утврђено да постоји позитиван тренд на нивоу значајности $\alpha = 0.05$.

Годишња сума падавина у осматраном периоду износи 592.21 mm, по којој Нишка котлина има субхумидну (полувлажну) климу на основу класификације климе по Азију. Упоредном анализом два тридесетогодишња периода, уочено је смањење количина падавина на годишњем нивоу у другом осматраном периоду за 23,84 mm.

Нишка котлина према Ланговом кишном фактору има хумидну климу и припада групи степа и савана. Грачанинов кишни фактор показује да Нишка котлина има изразито сушна лета са продуженим периодом аридности на септембар месец.

Индекс суше Де Мартона на годишњем нивоу износи 27,2, што Нишку котлину сврстава у области са егзореичним одводњавањем. Вредност индекса аридности Лобове од 0,76 показује да Нишка котлина има аридну климу у вегетационом периоду.

Комплетном анализом температура ваздуха и падавина, закључује се да постоји тенденција раста температуре ваздуха у другом тридесетогодишњем периоду, а истовремено опадање количине падавина у истом периоду. Треба нагласити да су јул и август месеци са најмање падавина и са највишим температурама ваздуха.

Израчунавањем агроклиматских показатеља, утврђен је благи пад вредности, како кишног фактора, тако и индекса суше у другом тридесетогодишњем периоду.

Хидротермички коефицијент по Сељанинову је рачунат за температурне прагове од 5°C, 10°C и 15°C. Нишка котлина се сврстава у трећу зону (0,7-1) по Сељанинову, са јасно израженим недостатком влаге, где је наводњавање оправдано само за основне културе током вегетационог периода. Постоји тренд пада вредности Ks у другом тридесетогодишњем периоду, што нам говори да се смањује влажност на подручју Нишке котлине.

Климадијаграмом је утврђено да се јул и август месец налазе на граници сушности и да је наводњавање основних култура неопходно.

Закључујемо да, ако се овакав климатски тренд настави, биће неопходно увођење одређених агротехничких мера у циљу одржања и побољшања пољопривредне производње на територији Нишке котлине.