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Journal of the Geographical Institute "Jovan Cvijić" 61(1) (13-30)

Original scientific paper UDC: 911.2:551.58(497.11)
DOI: 10.2298/IJGI1101013P

CLIMATE OF SOKOBANJA BASIN AND ITS INFLUENCE ON THE DEVELOPMENT OF AGRICULTURE

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Received 18 November 2010; reviewed 24 February 2011; accepted 20 April 2011

Abstract: The climate of Sokobanja basin has a significant influence on forming the economic character of this area. In the relation with other, primarily physical-geographical characteristics, climate of the Sokobanja basin has one of the greatest influences on the activities of the people who live there. The aim of this work is to analyze the basic climate elements and accordingly perceive their influence on the development of agriculture, as one of the most important activities of the population of this area.

Key words: Sokobanja basin, climate, climate elements, agriculture, development.

Introduction

Sokobanja basin is located in the central part of Eastern Serbia. It is situated between 43° and 44° of northern latitude and 21° and 22° of eastern longitude. Significant characteristic of its geographic position is the fact that it is, as for the regional geography, located in the system of spacious Carpathian-Balkan mountain range, whereas its smaller part in the west encroaches in the zone of old Rhodope mass (Ršumović, 1974). In a broader sense, this area belongs to mountainous-basin-valley macro region, whereas it belongs to meso-region of eastern Serbia (Marković & Pavlović, 1995). Such position of Sokobanja basin defines its particular climatic conditions which indirectly influence the very process of agricultural production.

The significance of agro-climatic studies of Sokobanja basin is great. This area was typical agricultural area up to the second half of the 20th century (Radivojević, 2008). Likewise, today's level of agrarian share in Sokobanja

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basin is very high, taken into consideration that agricultural area covers 30 357 ha, or 57.7% of the total basin surface (Diklić, 1962). Therefore, a special attention must be paid to the development of agriculture in this area. This is the reason complex agro-climatic studies can largely contribute to reviewing of basic trends of the development of agriculture. On the other hand, it would lead to overcoming uncontrolled development and optimal usage of natural potentials, which basically represents primary target of research in the work.

Basic aim of this work is valorization of climatic elements which are significant for the development of agricultural production. Since the aim of research was set in such a way, this work analyzes basic climatic elements (air temperature, precipitation, wind, air humidity, cloudiness and insolation). Accordingly, an attempt was made to determine structural characteristic of agricultural production of Sokobanja basin. It is possible to realize such aim of research only by using different research approach. Geographical (spatial) method, comparative, as well as statistical – mathematical method comprise the core of methodological procedure used in this work. It was necessary to apply statistical – mathematical method in order to define quantitative – qualitative characteristics, processes and figures which significantly influence the development of agriculture of Sokobanja basin.

Value mark of agro-climatic elements in Sokobanja basin is determined by a narrow database and lack of measurements of certain climatic elements in a long period. That is why reduced data for the thirty-year period from 1961-1990 and fifteen-year period from 1990-2005 have partially been used to analyze basic climatic parameters, which enabled their comparison. Shorter intervals were used for certain meteorological elements, because they had not been measured during the whole period of observation (Veljković, 1960). It has to be said that there are no first-order meteorological stations in the area of Sokobanja basin, so climatic characteristic of this area were obtained on the basis of the data from second-order meteorological station Sokobanja which is situated in the south-west part of the basin.

Likewise, some data were obtained approximately, that is, by calculating certain vertical gradients. Vertical gradients were determined according to Mt. Ozren, and only sea level was taken during calculation. Given the fact that the greatest part of the examined area which is attractive for agriculture lies in the altitude belt from 200 to 400m above sea level (hereafter m a.s.l.), evident unreliability of vertical gradients cannot significantly influence general value mark of agro-climatic elements.

Climatic conditions take up prominent place among natural conditions which are important for agricultural production. Agro-climatic characteristics determine structure of production, quantity of crop, quality of products and economic profitability of production of any agricultural crop.

General climate characteristics

Apart from general climatic factors, like geographic latitude and longitude, sea level, terrain exposition, climatic characteristic of Sokobanja basin are influenced by altitude, terrain exposition, expanding direction of mountains and valleys and openness of the basin towards the south (Radojković, 1904).

Sokobanja basin is climate-wise distinguished by certain specificities which are determined by its position, as well as its tecto-morphogenesis. It is surrounded by high mountains. Mountain of Rtanj (1 567 m) encloses the basin from the north; Mt. Ozren (1 186 m) is situated on the south, Mt. Devica (1 174 m) on the south-east, Mt. Slemen (1 098 m) on the east, whereas Mt. Bukovik (1 069 m) encloses the basin on the west. Isolated in such a way, the basin is opened only towards the south, where it reaches South Morava valley, narrow ravine and Bovan gorge, where continental influence comes from (Pavlović & Radivojević, 2009). In the east, Sokobanja basin is, through Skrobnička gorge, opened to the influence of continental air masses, which extend to it from eastern and northern Europe through Vlaška depression and Timok basin.

These morphological conditions influenced the creation of a special climate, temperature fluctuations, formation and level of atmospheric residue, wind frequency and intensity, that is, creation of special climatic characteristics of the basin (Jovanović & Radivojević, 2006). That is the reason, on the basis of conducted climatic regionalization of Serbia, Sokobanja basin is classified into Sokobanja – Knjaževac climatic region with moderate continental climate with warm summers and mild winters, as well as annual temperature amplitudes up to 23°C. This climate shows Mediterranean influences in some places in pluviometric regime (Rakićević, 1980). According to Koppen classification, there is a Cfwbx climate in Sokobanja, which means that the temperature of the coldest month is above -3 °C and below 18 °C, while average temperature of the hottest month is lower than 22 °C (Rakićević, 1976). Because of these climatic characteristics, the area of Sokobanja basin significantly differs from the other parts outside the basin which are not very far from Sokobanja.

The most important characteristics of this type of climate, as well as its influence on the development of agriculture, will be given in the overview and analysis of mean monthly air temperatures, mean monthly precipitation, winds, cloudiness and isolation.

Analysis of the main climatic elements

Air temperature

Air temperature, as one of the most important climate elements, is subject to complex research, especially in the second half of the 20th century. Analysis of this climatic element and an attempt to define regularities of its changes on a certain space is important above all, because of its influence on various human activities, especially on the development of agriculture.

Air temperature in the area of Sokobanja basin is conditioned by its geographical position, terrain configuration and sea level. (Dakić, 1967). The analysis of temperature regimes (Table 1) was done on the basis of thirty year periods from 1901 to 1991 and the period 1991 – 2005. The last period has a shorter sequence than the three previous ones, and it cannot be adequately compared to them, but it is important to analyze it because of pointing out to a trend of temperature changes by the end of 20th century. (Dimitrijević, Radivojević, & Filipović, 2010).

If we compare each of the above stated periods to mean temperatures of the 20th century (Table 1), which were obtained as arithmetic mean of three thirty year periods and the last one from 1991 – 2005, we get the following results:

- Mean annual air temperature in the first period from 1901 to 1930 was lower than the average temperature for 20th century by 0.2°C.
- January was the coldest month in both periods, whereas July was the hottest (in the period 1901 – 1930 both July and August had the same mean values of air temperature amounting to 20.5°C).
- The highest amplitudes of monthly values were recorded in the coldest month, January, which was colder by 0.9°C at the beginning of the century. The smallest differences of 0.1°C were recorded in March and August. The amplitude between mean monthly temperature of the hottest and the coldest month is higher by 0.5°C from the mean temperature for the 20th century, which is the consequence of significantly lower January temperatures in this period.

Table 1. Mean monthly air temperatures in Sokobanja basin (in °C)

Period	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year	Amp
1901-30	-2.5	0.3	5.1	10.3	16.5	19.5	20.5	20.5	16.2	11.0	4.8	0.5	10.2	23.0
1931-60	-1.2	0.2	4.6	10.6	15.8	19.2	21.4	20.7	16.5	10.9	5.6	1.9	10.5	22.6
1961-90	-1.4	0.8	5.1	11.1	16.0	19.2	20.9	20.4	16.4	10.4	5.2	0.8	10.4	22.3
1991-05	-0.3	1.1	5.4	11.2	15.8	19.0	20.8	20.6	16.2	11.0	4.8	1.4	10.6	22.3
20th C	-1.6	0.6	5.0	10.8	16.0	19.2	20.9	20.6	16.3	10.8	5.1	1.2	10.4	22.5

Source: Republic Hydroometeorological Service of Serbia, internal documentation;
Gotthard (1890-1910); Radojković (1926) – Climate of Sokobanja (1915-1926);
Republic Hydrometeorological Service of Serbia, internal documentation (1926-1930, 1931-1960);
Republic Hydrometeorological Service of Serbia, Belgrade, 2006.

Such changes in thermal regime are very important for perceiving the length of vegetation period. Vegetation period is different for various crops, its length being defined by biological temperature minimum needed for certain phases of vegetable development. For cool-season cereals, grass, and some industrial crops, vegetation period is the period with mean daily temperatures ≥5°C (hereafter MDT≥5°C). For corn, central European fruit and some vegetable crops, this is the period with mean daily temperatures ≥10°C (hereafter MDT≥10°C) (Đukić et al., 1995).

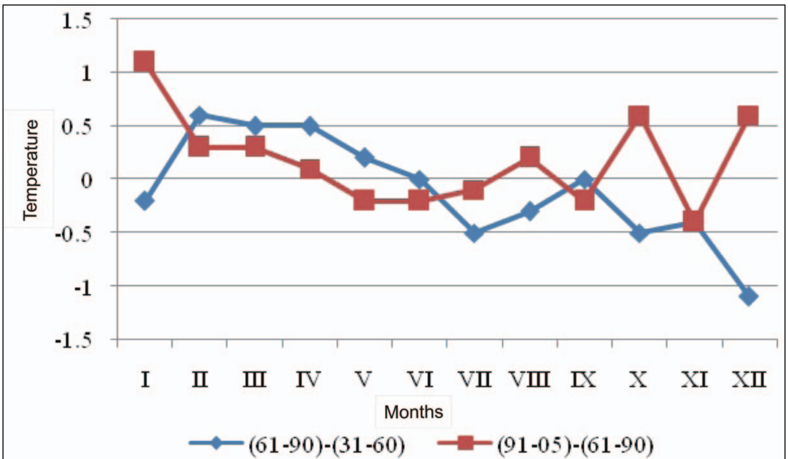

Figure 1. Temperature changes in different periods during 20th century

Vegetation period with MDT ≥5°C lasts for 258 days in the most part of Sokobanja basin (Table 2). In Sokobanja, where measuring station is situated in the south-western part of the basin on 298 m a.s.l. this period starts on the 15th of March and ends on the 1st of November. The length of vegetation period with MDT ≥5°C changes with the increase of sea level, that is, it is reduced on each 100 m approximately for 8 days.

Table 2. Average dates of the beginning, end and duration of periods with mean daily air temperatures ≥5°C and ≥10°C (1961-2005).

Station	Sea level	Temperature ≥5°C			Temperature ≥10°C		
		beginning	end	duration	beginning	end	duration
Sokobanja	300	15/03	01/11	258	10/04	20/10	193

Source: Republic Hydrometeorological Service of Serbia, Belgrade, 2006.

Vegetation period with mean daily temperatures ≥10°C is especially important for agricultural crops in Sokobanja basin, given the fact that most of the crops are biologically active during this period. Air temperature above 10°C appears in the valley belt of the basin in the end of the first decade of April and lasts as far as the end of the second decade of October. These temperatures last from 179 to 193 days. It is obvious that the differences in the length of this period are not conditioned only by sea level, but also by side slopes and relief exposition.

In fact, the length of vegetation period in non-exposed and south expositions is higher when compared to other expositions. In the profile Sokobanja – Ozren it is shorter for each 100 m for 7 days. The shorter vegetation period is, the lesser the choice of agricultural crops becomes, that is, shortening of vegetation period unfavorably influences the ripening of the crops which show higher demands for warmth, above all corn and beans.

What is also important for the development of agriculture is the distribution of thermal regime according to seasons (Table 3). If we analyze average seasonal temperatures, we can conclude that mean air temperature in the winter part of the year had negative value of -0.6°C only in the period 1901 – 1930. The amplitude between this and average value for 20th century, amounts to 0.7°C for winter. Spring and summer have the same mean value in both analyzed periods, whereas autumn is warmer on the century level by 0.1°C.

Table 3. Mean seasonal air temperatures in Sokobanja basin (C°)

Period	Winter	Spring	Summer	Autumn
1901-30	-0.6	10.6	20.2	10.6
1931-60	0.3	10.3	20.4	11.0
1961-90	0.1	10.7	20.2	10.6
1991-00	0.7	10.8	20.1	10.6
20th century	0.1	10.6	20.2	10.7

Source: Republic Hydrometeorological Service of Serbia, Belgrade, 2006.

On the basis of analyzed data we can conclude that, according to the average for 20th century, autumn is slightly warmer than spring. However, when spring is colder, the vegetables are less likely to die out from late spring frost, so the understanding of mean dates of late spring and early autumn frost is of great significance for agriculture.

On the basis of the data shown in table 4, but also on the basis of immediate terrain data, average limit of the occurrence of late spring frost goes from 30 March to 5 April, whereas the same limit for early autumn frost is the middle of October. As shown in table 4, mean date of late spring frost in this part of Serbia is in the first half of April, whereas the extreme month comes a month later, in the first half of May. From the aspect of vegetable production, May or late spring frost can be especially harmful, when the most agricultural crops are in the most sensitive phases of vegetation activities (germination phenophase). Early autumn frost occurs at the end of October, whereas extreme frost occurs in the second half of November. Extreme frost can significantly influence the shortening of vegetation period of many crops and cause much damage to agriculture. Crops that go through the most sensitive phases of development during spring (like cucumber, beans, potato, corn, etc.) are especially sensitive to extreme spring frost. These crops are mostly limited to the bottom of the basin, valley, and alluvial plane of the river of Moravica and its tributaries.

Table 4. Mean and extreme dates of frost occurrence in Sokobanja basin (1961-2005).

Mean frost date		Extreme frost date		Number of days of the longest frost period
First autumn	Last spring	First autumn	Last spring	
26 October	10 April	28 September	09 May	201

Source: Republic Hydrometeorological Service of Serbia, Meteorological observatory Niš, 2006.

Value grade of thermal conditions also includes the knowledge of mean maximum and minimum air temperatures (Maćejka, 2003). Lowest mean maximum temperatures in all the three observed periods were recorded in January, while the highest were recorded in August (Tables 5 and 6). From 1961 to 1990, mean minimum temperatures had higher values in January, March, April, May and October, while there was a drop in these values in the other months. The biggest change, that is, temperature rise, was recorded in April and May. It amounted to 1.2°C, while the highest drop was recorded in December the value of which was -1.2°C. On a yearly level temperature is higher by 0.1°C in the period 1961 – 1990. High air temperatures increase transpiration and complicate normal water supply. In table 5 we can see that the highest rise in temperature was recorded in April and May, when plants are on the beginning of vegetative period, which can negatively reflect the process of agricultural production without implementation of modern agro-technical measures. High temperatures, as well as small precipitation during summer condition drought, which can often have devastating consequences.

Table 5. Mean monthly maximum air temperatures in Sokobanja basin in given periods (C°)

	Period	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1	31-60	3.1	6.0	8.6	16.2	21.1	25.2	27.8	28.1	23.5	16.7	9.5	7.0	16.1
2	61-90	3.3	5.8	9.2	17.4	22.3	25.1	27.8	27.9	22.9	16.9	9.4	5.8	16.2
3	91-00	3.4	5.4	10.4	16.9	22.1	25.4	27.8	28.0	23.4	17.1	9.2	4.9	16.2
	2-1	0.2	-0.2	0.6	1.2	1.2	-0.1	0.0	-0.2	-0.6	0.2	-0.1	-1.2	0.1
	3-2	0.1	-0.4	1.2	-0.5	-0.2	0.3	0.0	0.1	0.5	0.2	-0.2	-0.9	0.0

Source: Hydrometeorological Service of Federal National Republic of Yugoslavia (1930-1950); Republic Hydrometeorological Service of Serbia, meteorological yearbooks (1961-1984); Republic Hydrometeorological Service of Serbia, archive data (1985-2005).

Lowest mean minimum temperatures in all the three observed periods were recorded in January, whereas the highest ones were recorded in July. In the period 1961 – 1990, mean minimum temperatures show higher values in March, April and June, whereas they drop in other months. The biggest change, that is, temperature drop, was recorded in December, and it amounted to 1.8°C. On yearly level, temperature is lower by 0.2 °C in the period 1961 – 1990.

Table 6. Mean monthly minimum air temperatures in Sokobanja basin in given periods (C°)

	Period	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1	31-60	-4.7	-3.5	-1.6	4.5	9.4	12.4	13.8	12.9	9.4	5.6	2.1	-0.6	4.9
2	61-90	-4.9	-3.8	-0.9	5.2	8.4	12.5	13.6	12.5	9.2	5.4	1.9	-2.4	4.7
3	91-00	-4.6	-3.9	-0.3	4.6	8.9	11.9	13.2	13.0	9.4	5.2	0.2	-2.9	4.6
	2-1	-0.2	-0.3	0.7	0.7	-1.0	0.1	-0.2	-0.4	-0.2	-0.2	-0.2	-1.8	-0.2
	3-2	0.3	-0.1	0.6	-0.6	0.5	-0.6	-0.4	0.5	0.2	-0.2	-1.7	-0.5	-0.1

Source: Hydrometeorological Service of Federal National Republic of Yugoslavia (1930-1950); Republic Hydrometeorological Service of Serbia, meteorological yearbooks (1961-1984); Republic Hydrometeorological Service of Serbia, archive data (1985-2005).

Average yearly temperature drop has a negative influence on vegetable crops. It is specifically characteristic for winter months, when temperature drop can harm winter crops. Also, low air temperatures during January, February and March can endanger nursery production in warm hotbeds.

Precipitation

Precipitation is the basic source of humidity and they represent limiting factor for survival and development of agricultural crops. Regardless of the quantity and regime, the soil absorbs the highest sum of atmospheric residue during vegetation period. Intrusion of humidity and cold air masses from the Atlantic Ocean, warm areas around Mediterranean, as well as winter intrusions of cold air masses from northern Europe and Russia have dominant influence on pluviometric regime of Sokobanja basin. West winds bring the highest amount of precipitation to the area of Sokobanja basin.

During 20th century Sokobanja basin took on 637 mm of atmospheric precipitation on average. However, yearly distribution of atmospheric precipitation changes with the rise of altitude, so the bottom of the basin and alluvial plane of the river of Moravica, as agriculturally most significant regions, take on 578 mm of precipitation yearly, whereas mountain rim takes on significantly more. In fact, there is 808 mm of atmospheric precipitation on the mountain rim. Thus, on each 100 m of height, the amount of precipitation enhances by 57.5 mm. On the basis of the gradient of precipitation rise calculated in such a way, we can derive that hypsometric belt from 400 – 600 m a.s.l. has 698.7 mm of atmospheric precipitation annually, while mountain rim, which is located over 1 500m (Rtanj – Šiljak – 1 567 m) as much as 1302.4mm of atmospheric precipitation (Ducić & Anđelković, 2005).

Table 7. Precipitation regime in Sokobanja basin in given periods (mm)

Periods	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1901-1930	40	33	36	59	67	68	48	36	32	62	53	44	578
1931-1960	36	39	31	51	67	62	54	42	42	63	60	52	599
1961-1990	48	50	53	73	85	76	52	56	49	52	67	60	711
1991-2005	47	48	49	54	65	66	58	49	48	46	65	67	663
20th century	44	42	42	59	71	68	53	45	43	55	61	55	637

Source: Hydrometeorological Service of Federal National Republic of Yugoslavia (1957-1991), Rakićević (1976, 1952), Republic Hydrometeorological Service of Serbia, meteorological yearbooks (1961-1984); Republic Hydrometeorological Service of Serbia, archive data (1985-2005).

Distribution of annual sum of precipitation by months is very important for agriculture. In this respect, we can observe two maximums and two minimums of precipitation in the area of Sokobanja basin. Spring maximum is more pronounced than the autumn one, which is more favorable for crops, since they need more humidity in the period of germination. Winter minimum of precipitation is more pronounced than the summer one. This is greatly significant for agriculture since all the crops need humidity during summer because of the increased insolation.

Amount of precipitation during vegetation period is also of crucial importance for the development of all agricultural crops. Atmospheric precipitation is evenly distributed during vegetation (period April – September is roughly taken). During this time there is 408 mm of atmospheric precipitation, or 70.5% of total yearly amount. The height of water residue in vegetation season is enhanced with the rise in sea level, so foothills, situated within hypsometric belt from 400 to 600 m, take on 520 mm of atmospheric residue in vegetation period. Precipitation, outside vegetation period, especially during the colder part of the year (from October to March), are usually accumulated into the soil and serve as pre-vegetation reserves of humidity which plants use in the first part of vegetation period. Profuse precipitations by the end of spring and beginning of summer contribute to the improvement of water balance in the soil in this period.

In the area of Sokobanja basin the smallest amount of precipitation happens in summer months. In meteorological station Sokobanja in the valley of Moravica, there is 45 mm of atmospheric residue in July and 43 mm in August. If we take into consideration that summer temperatures are high and precipitation is oozed in the form of showers, then humidity deficit becomes even more pronounced.
There are 106.8 rainy days on average during year in the area on Sokobanja basin. Spring rains are strong and irrigate the soil a lot. Unlike them, summer rains are showery and are only of use for crops in the alluvial plane. In steep terrains, these rains are more harmful than useful because they lead to enhanced denudation.

Table 8. Mean number of snowy days in Sokobanja basin (1961-1990)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean number of snowy days	6.4	5.1	3.3	0.3	-	-	-	-	-	-	0.9	7.0	24.0

Source: Republic Hydrometeorological Service of Serbia (1961-1990).

From the range of precipitation regime, the data on the number of snowy days, as well as the mean number of days with snow cover are also important for the development of agriculture. This is especially important for winter crops. There are 24.0 snowy days a year in the area of Sokobanja basin. The highest mean number of days occurs in December. In this period snow, as a good insulator, positively influences the protection of winter crops from low temperatures.

Table 9. Mean number of days with snow cover in Sokobanja basin (1961-1990)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean number of days with snow cover	11.2	8.2	3.8	0.2	-	-	-	-	-	-	0.3	9.1	32.8

Source: Republic Hydro meteorological Service of Serbia (1961-1990).

Winds

Apart from positive influence on vegetation (pollination), winds also have negative effect on agricultural production. Strong winds damage perennials, because lying of many agricultural crops (wheat, barley, alfalfa), destroy greenhouses, and so on. Likewise, winds enhance transpiration of soil and vegetables.

Configuration of air flows in Sokobanja basin is modified by local conditions. Because this area is surrounded by mountains from all sides, the winds that blow there have the character of invasive winds. Being surrounded by mountains is a barrier for cold winds from north, north-east and east, therefore cold air flow is significantly weakened in this area (Jovanović, 1923). According to general division of atmospheric pressure in the area of Sokobanja basin, winds from north should be most expected. However, since air flows in this area are subject to the influence of relief, the winds from west and east quadrant.

Table 10. Mean frequency of winds in Sokobanja basin in ‰ (1965-2004)

Period	N	NE	E	SE	S	SW	W	NW	C
1956-2005	53	26	76	104	22	39	118	97	49
Speed in m/s	3.4	2.5	2.7	3.9	2.5	2.1	2.5	2.2	-

Source: Republic Hydrometeorological Service of Serbia (1965-2005).

Dominant wind of Sokobanja basin, as well as the whole of eastern Serbia is košava (a type of south-eastern wind). East winds most often occur in spring and autumn, and most rarely in winter and summer (Ducić & Radovanović, 2005). The wind from western quadrant is also very important, its frequency being 118‰, which makes it the most frequent wind. Other directions are rare, their frequency is 30-40% and they represent the consequence of local air flow, as well as local flows due to terrain exposition. When it comes to wind velocity, the wind from the north-eastern direction has the highest average speed of 3.3 m/s. West wind, which is the most common in this area, has the average speed of 2.5 m/s. Winds from the east and south quadrant have negative effect from the aspect of agricultural production.

These winds dry out the soil during vegetation period and enhance transpiration with agricultural crops. Winds from north direction lower air temperature in winter and thus endanger nursery production (in hotbeds), but winter crops as well.

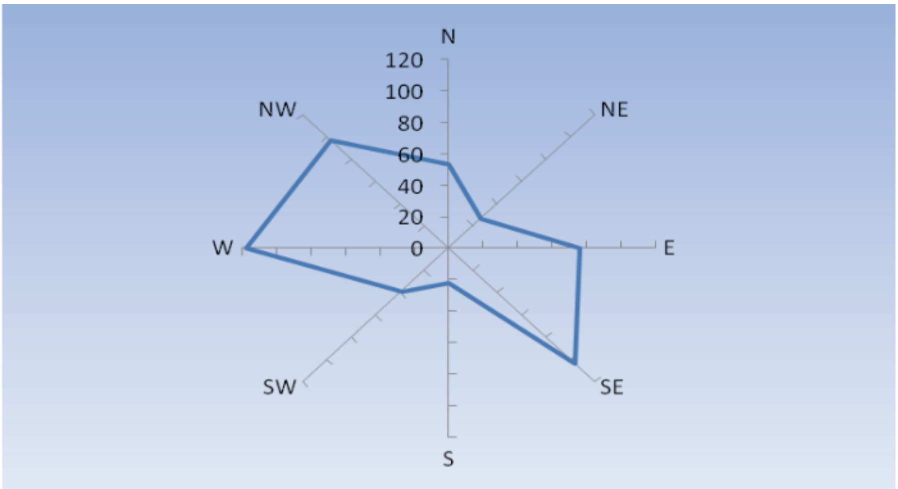

Figure 2. Wind rose in the area of Sokobanja basin

Air humidity

Air humidity is an important agro – climatic element. Its climatic values depend on temperature and the winds. Humid air reduces, whereas dry air enhances vegetable transpiration. That is why the intensity of vegetable transpiration, and therefore their development, depends on the value of air humidity.

Table 11. Mean monthly values of relative air humidity in Sokobanja basin in given periods (%)

Periods	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1961-1990	82	81	75	68	71	72	70	69	72	75	77	83	75
1991-2005	83	83	80	75	76	75	71	72	78	81	83	84	78

Source: Republic Hydro meteorological Service of Serbia, meteorological observatory Niš (1961-2006).

The best indicator of air humidity is its relative humidity, which stands for the degree in which the air is saturated with vapor. The area of Sokobanja basin is characterized by higher air humidity which is the consequence of low mean winter temperature, as well as its significant woodiness.

In the period 1961 to 1990, mean value of relative air humidity was the highest in December, January and February, while it was the lowest in April and August. On a yearly level, during the analyzed period, Sokobanja basin had an average value of 75%. Values of relative air humidity in the following period, from 1991 to 2005 show identical characteristics like the previous one. On a monthly level, the biggest difference occurs in September, which distinguishes itself with enhanced humidity of 6% when compared to September from the period 1961to1990. Likewise, on a yearly level, period 1991 – 2005 (although it was half shorter) distinguish itself by enhanced humidity of 78%, which is mostly the consequence of growth in average winter temperature in the appropriate period.

By analyzing relative air humidity of tow observed periods, we can conclude that it mostly has normal annual flow. Higher values during the whole observation period were recorded in the colder part of the year, while lower values were recorded in spring and summer. According to that, values which are the consequence of the pace during the year with two maximums and two minimums were obtained. Likewise, the two periods point to the fact that relative air humidity in a long interval changes slowly, especially on mean monthly and yearly level.

Low values of relative air humidity during summer part of the year influence agricultural crops, especially arable crops, very negatively. However, somewhat lower negative values of relative air humidity during April enhance the danger of late spring frost.

Cloudiness

Cloudiness influences the length of sunshine, air temperature and its oscillation, precipitation, and so on. This is an important agro–climatic element which in its yearly course coincides with the yearly course of relative air humidity.

Table 12. Cloudiness in the area of Sokobanja basin in the given periods

Period	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
61-90	7.0	7.1	6.1	5.4	5.3	4.8	3.7	3.1	3.6	5.0	6.9	7.0	5.4
90-05	6.9	6.1	5.8	5.4	5.0	4.4	3.5	3.0	3.9	4.9	6.3	7.0	5.2

Source: Republic Hydrometeorological Service of Serbia, climate atlas (1931-1960);
Republic Hydrometeorological Service of Serbia, meteorological yearbooks (1961-1984);
Republic Hydro meteorological Service of Serbia, archive data (1985-2000).

The highest cloudiness in the area of Sokobanja basin, in the period 1961 – 1990 occurred during winter (December 7.0 tenths of the sky covered by clouds, January 7.0), with its maximum value during February – 7.1. The months of July, August and September on average have 3.1 to 3.7 cloudy days. Average cloudiness on a yearly level, during the period analyzed, is 5.4 cloudy days a month. Other analyzed period, 1990 – 2004 is characterized by lower cloudiness both on a monthly and yearly level. Winter months also have maximum cloudiness (December 7.0, January 6.9 and February 6.1), whereas August is the month with minimum cloudy days, all in all 3.5. By comparing these two periods (although they are not of the same length), we can notice that the biggest differences occur in the winter half of the year, where the first analyzed period was significantly cloudier. Cloudiness regime, in the last decade of the 20th century, is expressed by the number of cloudy and sunny days, shows the tendency of reduction, which is the most obvious in summer months, when there are three to four cloudy days on average. Higher cloudiness in winter months abates daily oscillations of air temperature, which favorably influences winter crops and permanent crops (fruit). As opposed to that, low sky coverage with clouds in summer months (July and August) in combination with other, unfavorable agro-climatic conditions for that period, influence the appearance of drought (Dinić, 1998). Somewhat lower values of cloudiness during September and October extend vegetation period and contribute to product ripening with agricultural crops which show higher demands for warmth (Marković, 1993).

Insolation

Insolation is one of the most important factors of plants' growth and the element of soil fertility, because it influences the processes of vaporization from soil, as well as the speed and direction of complex chemical and physical – chemical processes (Đukić et al., 1995). The intensity of photosynthesis, and by it creation of organic matters directly depends on this climatic element. Insolation influences the size, but also the quality of the product, on the quantity of sugar in fruit, the quantity of starch in potato, the quantity of oil in sunflower seed, and so on.

Table 13. Average duration of sunshine in the area of Sokobanja basin (monthly and daily in h) in the period 1961-2005 (1st – 1961-1990; 2nd -1991-2005)

Period		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1st	Mon.	59	74	121	161	201	224	267	262	208	158	78	48	1862
	Daily	1.9	2.6	3.9	5.3	6.4	7.4	8.6	8.4	6.9	5.0	2.6	1.5	5.1
2nd	Mon.	65	87	141	166	221	245	281	271	201	147	86	55	1975
	Daily	2.4	3.1	4.5	5.5	7.1	8.1	9.0	8.7	6.7	4.7	2.9	1.8	5.4

Source: Republic Hydrometeorological Service of Serbia, Climate atlas;
Republic Hydrometeorological Service of Serbia (Meteorological yearbooks 1961-1984);
Republic Hydrometeorological Service of Serbia (archive data (1985-2000).

Average yearly insolation in Sokobanja basin, during the 1st period, amounts to 1862 sunshine hours, with its peak in July with 267 hours or 8.6 hours a day on average. December is the month with the least sunshine hours, that is, 48, or 1.5 hours a day. There are 59 hours, that is, 1.9 hours a day in January. When compared the period 1961-1990, with the following period (the 2nd) is characterized by enhanced insolation in the warmer part of the year (the biggest difference occurs in June, 0.7 hours a day). January and February are also distinguished by enhanced insolation, and the difference amounts to 0.5 hours a day. On a yearly level, last decade of 20th century has enhanced insolation value for 1975.4 hours, with his peak in July with 281,4 hours or 5.4 hours a day on average. If we observe it by months, insolation sums differ. On the basis of the length of sunshine, we can conclude that daily insolation shows the highest values in July and August, respectively 9.0 and 8,7 hours a day. These months take up around 38% of the total insolation sum in vegetation period.

Conclusion

Sokobanja basin has, as a central Balkan basin, a significant natural potential which has made it attractive for settlement and economic activities since the earliest periods of human civilization. Alluvial plane of the river of Moravica, river terrace, as well as mild relief forms of the basin and orbital foothills have, together with other factors, enabled favorable conditions for the development of agriculture. That is why agricultural activity in this area was the main economic activity up to the second half of the 20th century, so the process of anthropogenization of geographic centers bore the marks of agrarian territorial conquest for centuries. Development, modern topology and the structure of agricultural production of Sokobanja basin is determined by numerous natural and social factors. Climatic characteristics of this area take up significant place among natural factors. State and value grade of agro-climatic elements, presented in the previous part of the text, point to the fact that the climate in this area also appears as a limiting factor of agricultural production.

Most of agro-climatic parameters favorably influence the development of agricultural crops, especially in lower hypsometric zones. Since vegetable crops start germinating on 5°C, vegetation period in these lower hypsometric belts in the area of the basin lasts for 7.5 months or 246 days. This is primarily related to valley and foothills belts between contour lines 400-600 m. However, value mark of agro-climatic conditions changes with the rise in sea level. Average air temperature drops, average yearly amount of atmospheric precipitation rises, as well as cloudiness, while insolation drops. All this leads to reduction of vegetation period, 7-8 days on average on each 100 m of height.

Such relations of agro–climatic conditions also determine both special structure and layout of agricultural production. The valley belt and foothill belt, according to agro–climatic conditions tested in the work, are suitable for the development of agriculture (wheat, corn, barley, and some other industrial crops), whereas mountain rim of the basin is suitable for the development of cattle-breeding (cattle breeding for milk in lower and sheep-breeding higher hypsometric belts). Such spatial and structural organization would lead to improvement in agricultural production, which would, on the other hand, lead to significantly better economic effects out of this activity. In a rational, when compared to natural conditions, market – oriented agricultural production, Sokobanja basin could become a significant producer of many agricultural crops and livestock products. In this way, agricultural production could not only completely satisfy the needs of local population and food industry, but also create market surplus which could be placed both on the market of eastern Serbia and the markets of more distant areas.

Acknowledgements
This paper is the result of the project 176008 funded by the Ministry of Education and Science of the Republic of Serbia.

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