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YIELD AND QUALITY OF GRAPES OF AUTOCHTHONOUS VARIETY VRANAC IN AGROECOLOGICAL CONDITIONS OF PODGORICA SUBREGION

Abstract: The study of the climatic factors influence on the yield of grapes, the cluster mass, the content of sugar and acids in the Vranac variety was performed at the Biotechnical Faculty in Podgorica in the three years period, 2011–2013.

The highest yield of grapes and cluster mass was achieved in 2012 (1.41 kg m^2 and 228 g), while the lowest values were determined in 2013–1.21 kg m^2 and 186 g. The highest sugar was measured in 2012 (23.8%), while the lowest content was determined in 2013 (21.6%). The highest acid content in grape juice was recorded in 2013 (6.08g/l), which was a direct consequence of abundant precipitation during the growing season, especially in August and September.

The results of the research showed that the yield and quality of the grapes were in direct accordance with the meteorological conditions. In the studied period, the average yield was 13.2 t/ha, sugar content about 23% and acid 5.5 g/l. This suggests that despite the growing climate change, with the application of intensive agro-technology, high yields of good quality grapes can be achieved in the production of the Vranac variety.

Key words: *Vranac, climatic factors, yield, quality of grapes*

INTRODUCTION

The climate influence on plant production is expressed by the complex action of its factors, that are mutually conditioned and altered. From a large number of production factors, relief, exposure, temperature, light, physical and mineral properties of soil [17] show the greatest importance to the

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growth and development of the grapevine. Climate changes are occurring in a smaller or larger extent in every part of the world — from equator to poles [3], and their effects are evident in many vineyard areas. This influence is mostly manifested in changes that occure in certain phenological phases of development, as well as harvest dates [4].

The Podgorica subregion, thanks to favorable climatic and soil conditions, represents a very suitable area for successful vines cultivation. However, in recent years in this area there has been an increasing deviation of climatic parameters, due to which the usual weather conditions have been significantly impaired [11]. A large number of parameters indicate that the climate here is changing rapidly: the number of days with tropical temperatures is increasing, the periods of drought are longer and more frequent, especially during the vegetation period of the vine, the number of days without rain is increasing, as well as the intensity of precipitation. Such climate change increasingly leads to significant oscillations in yield and quality of grapes. Consequently, there is the constant need to examine the impact of the changing climate on the agro-biological and economic-technological characteristics of cultivated grape varieties in Montenegro.

Vranac is the leading grapevine variety for the production of high-quality red wines in Montenegro. According to Ulicevic [16], this variety also can be found under other names: Vranac krstač, crmnička loza, Vranac crmnički. The origin of these synonyms is related to the Crmnica and to the exceptionally black color of ripe berries. This variety, beside Montenegro, is also growing in Macedonia and sporadically in Dalmatia, Herzegovina and Serbia [2].

Bearing in mind the above mentioned, research has been carried out with the aim of studying in detail the influence of the main climate parameters, on the yield and the quality of Vranac variety grapes in the Podgorica subregion.

MATERIALS AND METHODES

The study of the climatic factors influence on the yield and grape quality of the Vranac variety was carried out during 2011, 2012 and 2013. The research was carried out at the Biotechnical Faculty in Podgorica. The vineyard was planted in 2005 with a spacing between rows 2.5 m and 1 m between the vines in a row. The cultivation form of the vine two pointed horizontal cordon with a tree height of about 80 cm. A mixed prunning is applied. The research was carried out on 30 vines, i.e. in three repetition with 10 vines.

During the three year research, the yield (kg/m^2), cluster mass (g), sugar content (%) and acid (g/l) in must were examined. Grape yield was obtained by measuring harvested grapes and calculating grape yield per m^2, and

the cluster mass was determined from the ratio of the yield obtained from ten vines and the number of clusters. The proportion of sugar in grape juice was determined by aerometric (hydrometer), and the proportion of total acids in grape juice by neutralizing all the acids and their salts with n/10 NaOH using the indicator bromtimol blue.

In the analysis of climatic conditions of Ljeskopolje, data from the meteorological station in Podgorica were used. Statistical analysis of the obtained results was performed using variance analysis and LSD test.

RESULTS AND DISCUSSION

Climatic, i.e. meteorological conditions that prevail in production vineyards significantly influence the yield and quality of grape [7]. Of all climate parameters, the strongest influence on the phenolic dynamics of the grapevines is temperature and climate impact is the most expressive in the thermal regime.

Table 1. Average monthly, annual and vegetational air temperature (°C)

Year	Months												Avarage annual	Avarage vegetational	Vegetational suma
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII			
2011.	5.8	7.8	1.7	16.8	20.3	25.6	27.2	29.3	26.3	16.3	9.9	8.0	17.0	23.1	4947.1
2012.	4.9	3	13.1	14.5	19.9	27.3	30.4	29.7	23.9	18.2	13.3	5.6	16.2	23.4	5007.6
2013.	6.7	7.7	10.8	17.1	20.1	24.5	28.5	28.8	21.3	16.7	12.5	6.6	16.8	22.4	4793.6
2011–2013.	5.8	6.2	8.5	16.1	20.1	25.8	28.7	29.3	23.8	17.0	11.9	6.7	16.5	23.0	4916.1
1985–2010.	6.2	7.4	10.5	15.8	20.5	24.4	28.0	27.6	21.6	16.2	10.8	7.3	16.3	22.0	4715.3

Table 1 clearly shows that the temperature of air in Podgorica's subregions records constant growth, especially in the summer period. If we analyze climate anomalies, expressed through differences in the value of climatic parameters between the perennial averages (1985–2010) and the period from 2011 to 2013, we come to solid evidence that the climate in this vineyard is rapidly changing. In comparison with the annual average, the average annual air temperature in 2011 was 0.7 °C higher compared to the annual average, in 2013 by 0.5 °C, while in 2012 it was at the level of perennial averages. The average temperature of the vegetation period in the three-year average was 23 °C, which is 1 °C higher than the perennial average. In the second research year, the average vegetation temperature was 23.4 °C and was slightly higher than the first one (23.1 °C), and significantly higher than the

third year in which the average temperature during the vegetation was 22.4 °C. The average sum of active temperatures in the period of vegetation for the period 1985–2010 was 4715.3 °C, while in the studied period it was significantly higher — 4916.1 °C. In the studied period, the largest vegetation sum of temperature degrees was in 2012 (5007.6 °C).

Table 2 shows that the period May — June — July — August in 2012 had significantly higher maximum air temperatures compared to the same period in 2011 and 2013. In other months, the maximum air temperature was at an approximate level. In 2012, during the period from May to September, the highest minimum air temperatures were measured (Table 3).

In recent years, the number of summer days in which the maximum daily temperature has reached over 25 °C during the day, has increased significantly in Podgorica's vineyard. Tropical character has 59% of June, 87% of July and 86% of August days. The high tropical temperature, when the maximum daily temperature reaches 35 °C, has 15% of the day in June, 40% in July and 45% in August [5]. Also, the average number of summer days has increased (the maximum daily temperature has reached 25 °C over the day), from 129 to 145 days.

Table 2. Absolute maximum air temperature

Year	Months												Annual max
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2011.	16.6	21.3	23.7	27.6	31.5	37.6	39.9	41.2	37.8	31.0	21.9	16.8	41.2
2012.	15.7	19.3	26.3	31.1	33.5	38.3	40.7	44.0	36.1	33.6	22.6	15.4	44.0
2013.	16.7	17.2	20.3	32.6	34.1	38.4	39.4	41.3	31.9	29.2	24.8	17.8	41.3

Table 3. Absolute minimalne air temperature

Year	Months												Annual min
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2011.	-3.0	-3.1	-2.3	4.7	9.9	16.7	14.9	16.9	17.5	2.9	0.3	-2.6	-3.1
2012.	-5.5	-5.7	2.5	0.4	10.7	14.9	19.6	17.7	10.9	7.2	4	-5.5	-5.7
2013.	-2.3	-2.3	-0.6	8.6	10.0	11.3	16.9	18.5	11.1	1.7	-1	-3.3	-3.3

The results given in Table 4 show that in Podgorica's subregion the average annual amount of precipitation for the period 1985–2010 was 1777.5 mm, while in the study period (2011–2013) it was lower and amounted to 1683.1 mm. From the given data it can be seen that there were no significant changes in the amount of precipitation during the observed periods, but the changes were significant in the precipitation regime (pronounced rain and dry periods during the year). In 2011, the annual precipitation amounted to

Table 4. Monthly, annual and vegetational and precipitation (mm)

Year	Months												Annual sum	Vegetational sum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2011.	79.5	113.8	100.5	44.1	89.5	25.8	31.4	2.1	43.3	73.6	37.1	254.2	894.9	309.8
2012.	60.3	200.9	0.0	351.2	132.0	33.7	11.3	0.5	86.6	296.3	285.8	305.0	1763.6	911.6
2013.	324.3	246.8	518.6	101.2	211.2	51.0	10.3	123.1	178.4	239.3	341	45.8	2391.0	914.5
2011–2013.	219.8	203.3	220.5	165.5	144.2	36.8	17.6	41.9	102.7	203.0	309.0	231.0	1683.1	711.8
1985–2010.	195.1	190	210.9	103.9	68.5	102.1	21.3	56.6	115.4	181.6	289.3	242.8	777.5	649.5

only 894.9 l/m^2, or 882.6 l/m^2 less compared to the perennial average. In the second year of the research, the annual precipitation (1763.6 mm) was at the level of perennial averages, while in the third year it was significantly higher and amounted to 2391 l/m^2.

If we observe precipitation in the vegetation period (Table 4), it can be seen that in 2011 only 309.8 l/m^2 of rain fell, that is significantly less compared to 2012 and 2013 in which the vegetation a period measured 911.6 l/m^2, or 914.5 l/m^2 of water sediment. It is interesting to note that in 2013, for the first three months, record quantities of rain were measured — 1090 l/m^2. The highest rainfall in this year fell in March — 518.6 mm, which is three and a half times more than the usual rainfall this month. Since rainfall in Montenegro (64 years) have been measured, it did not happen that in March this rain fell [6].

Average precipitation during grapevine vegetation in the period 2011–2013 was 711.8 l/m^2. Although in the studied period, in comparison to the perennial average (649.5 l/m^2), more precipitation is registered, this does not mean that the grapevines in these years was sufficiently provided with water. Namely, in 2011 and 2012, the precipitation schedule was rather unfavorable, with a pronounced deficit in the hottest period of the year.

From the results shown in Table 5 it can be seen that the achieved grape yield was in accordance with meteorological conditions at the level of the studied years. The lowest grape yield (1.21 kg/m^2) was measured in 2013, in which the highest precipitation fell, both on an annual level and during the growing period.

Table 5. Yield and grape quality of Vranac variety

Year	Grape yield (kg/m^2)	Cluster mass (g)	Sugar content (%)	Total acid content (g/l)
2011.	1.35	208	23.2	5.18
2012.	1.41	228	23.8	5.47
2013.	1.21	186	21.6	6.08
Average	1.32	207	22.8	5.57
LSD 0.05 0.01	 0.178 0.181	 9.22 10.69	 0.59 0.85	 0.46 0.67

This year, a very strong intensity of plant diseases was recorded, which, in addition to a significant decrease in yield, due to increased use of chemicals, significantly increased production costs. The highest yield was measured in 2012 (1.41 kg/m2), while in 2011 it was 1.35 kg/m^2. Statistical data processing revealed that the yield of grapes in 2012 was significantly higher compared to 2013, and only significantly higher than in 2011. The difference in grape yield between the first and third year of the study was not statistically significant for any level of probability. The yields realized in all the studied years were at the level that other authors mention for the variety Vranac [1, 2, 12].

Analyzing the average values by years of research, it can be noticed that in 2012 the cluster mass was significantly higher compared to 2013 and only significantly higher than in 2011. The higher average cluster mass in the first two years of the experiment (208 and 228 g) is due to significantly more favorable ecological conditions in those years, especially temperature. During these years, the average air temperature in the vegetation period was significantly higher compared to 2013. The obtained results are in accordance with previous results [13], who stated that the mass of the grape variety in the Podgorica vineyard was also higher in climatically favorable years. The average cluster mass in these researches was at the level of values that Pejović i sar. [12] and Pajović et al. [9] indicate in the same agroecological conditions for the Vranac variety.

The ecological potential of the production areas has a significant impact on the quality of the grapes, primarily on the content of sugar and acids. The quantity of sugar in the grapes, apart from the variety, depends significantly on the degree of maturity and grapes health, as well as from the climatic conditions in the grape maturing phase [14].

Based on the results shown in Table 5 it can be seen that the highest content of sugar in the grape is measured in 2012 (23.8%) and the lowest in 2013 (21.6%). This is a direct consequence of the various meteorological conditions that prevailed during the years of the experiment. In 2013, which had the lowest average vegetation temperature of the air and the highest amount

of precipitation in the vegetation period, the lowest content of sugar in the must was determined. Vukosavljević et al. showed similar results[18], and found higher sugar content in must in years with higher average vegetation temperatures. The importance of production conditions on yield and grape quality is also indicated by Santalucia et al. [15] and Mota et al. [18].

Acids ratio in the must is an important indication of the grapes quality, since the taste and harmony of the produced wine depend on their presence. The results of the three-year experiment showed that the average acid content in the must was satisfactory and characteristic for the Vranac cultivated in the agroecological conditions of the Podgorica subregion. The highest acid content in th must was determined in 2013–6.0 g/l, which is a consequence of higher precipitation during the maturing period, especially in August and September (123.1 and 178.4 l/m^2). Such conditions significantly influenced the grapes quality, primarily on the content of the acids. Statistical analysis of data showed that in 2013 the acid content was significantly higher compared to other studied years. These results are in accordance with the results of Pejović et al. [12] and Pajović et al. [10].

CONCLUSION

Based on the conducted research, it can be concluded:

— The average yield of grapes in the three-year period was 13.2 t/ha, the content of sugar was 22.8%, and acid 5.5 g/l. The yield of grapes and cluster masses were the lowest in 2013, which is interpreted as a large amount of precipitation during the vegetation period of the grapevine.

— Very high sugar content was measured in 2011 and 2012 (23.8% and 23.2%) as a result of higher average air temperatures in the vegetation period of the grapevine.

— The highest acid content was established in 2013, which is due to large amount of precipitation in August and September.

— The results of these studies have pointed out the significant influence of climate factors on the yield and quality of the yield of this variety. Nevertheless, despite the growing influence of climate change in Podgorica's subregion, there are still very favorable agroecological conditions for the cultivation of Vranac.

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VISINA I KVALITET PRINOSA AUTOHTONE SORTE VRANAC U AGROEKOLOŠKIM USLOVIMA PODGORIČKOG SUBREGIONA

Sažetak

Proučavanje uticaja klimatskih faktora na prinos grožđa, masu grozda, sadržaj šećera i kisjelina u širi sorte vranac obavljeno je na Oglednom imanju Biotehičkog fakulteta u Podgorici u periodu 2011–2013. godine.

Najveći prinos grožđa i masa grozda ostvareni su u 2012. godini (1,41 kg/m^2, odnosno 228 g), dok su najmanje vrijednosti utvrđene u 2013. godini — 1.21 kg/m^2, odnosno 186 g. Najviše šećera u širi izmjereno je takođe u 2012 (23,8%), dok je najmanji sadržaj utvrđen u 2013. godini (21,6%). Najveći sadržaj kisjelina u grožđanom soku evidentiran je u 2013. godini (6,08g/l) što je bila direktna posljedica obilnih padavina tokom vegetacionog perioda, a posebno u avgustu i septembru.

Rezultati istraživanja su pokazali da su prinos i kvalitet grožđa bili u direktnoj saglasnosti sa meteorološkim uslovima. U proučavanom periodu ostvaren je prosječan prinos grožđa na nivou od 13,2 t/ha, sadržaj šećera oko 23% i kisjelina 5,5 g/l. Ovo ukazuje da se u proizvodnji sorte vranac, i pored sve izraženijih klimatskih promjena, uz primjenu intenzivne agrotehnologije mogu postizati visoki prinosi dobrog kvaliteta grožđa.

Ključne riječi: vranac, klimatski faktori, prinos, kvalitet grožđa