INFLUENCE OF THE ROOTSTOCK P1103 AND SO4 ON THE BIOLOGICAL CHARACTERISTICS OF THE CABERNET SAUVIGNON VARIETY

Zoran PRŽIĆ, Nebojša MARKOVIĆ, Isidora ILIĆ
Faculty of Agriculture University of Belgrade, Nemanjina 6, Belgrade, Serbia

Corresponding author email: zoranata4@yahoo.com

Abstract

Cabernet Sauvignon is one of the most widespread grape varieties, both in the world and in Serbia and is used for the production of high quality red wines. The rootstocks P 1103 and SO4 are widely used in Serbian viticulture. The choice of rootstock can significantly influence the biological characteristics of cultivated variety, especially through qualitative parameters of bunch and the berry.

The research was conducted in the wine-growing region of Šumadija. The vineyard was planted in 2009 with a row spacing of 2.3 m and between rows 0.8 m. The aim of the work was to determine the influence of rootstock P1103 and SO4 on the biological characteristics of the Cabernet Sauvignon variety. The work contains data related to phenological observations, vegetative and reproductive potential, yield, uvological composition of grapes and berries, and qualitative characteristics of grape juice.

Phenological observations revealed no differences in the length of phenophases. A higher average shoot growth was observed on rootstock P 1103 (150.9 cm). A higher number of developed inflorescences (13.7) was observed on rootstock SO4, while the average yield was higher on rootstock P 1103 (1.723 kg).

The uvological observations of bunches and berries showed higher values on the rootstock P 1103 for the following parameters: average weight of the bunch (175.4 g), number of berries in the bunch (151.6), weight of the bunch stem (5.5 g), weight of skin of 100 berries (11.9 g) and seed mass of 100 berries (7.2 g). The sugar content of grape juice was higher in rootstock P 1103 (27.16%), while the content of total acids was generally higher in rootstock SO4 (8.3 g/l).

Key words: rootstock, P1103, SO4, Cabernet sauvignon, grape

INTRODUCTION

According to the International Organization of Viticulture and Wine (OIV), there will be a significant decline in vineyard area worldwide between 2000 and 2021. In 2021, 7.3 million hectares will be planted with vines. Cabernet Sauvignon plays a key role in the overall range of noble cultivated vines. It originates from the Bordeaux region of France and is one of the best representatives of the French noble wine grape varieties.

It ranks 6th in France and covers 48.000 hectares (OIV, 2019). The countries with the most vineyards planted with this variety are China, France, Chile, USA, Spain, etc. In Serbia, Cabernet Sauvignon is cultivated on 2.111 ha (Przic, 2019), mainly in the Tri Morava region (34.86%), followed by Srem (15.72%) and Šumadija (9.36%).

All grape varieties should be grafted onto some rootstock vines, as the root of the noble vine is sensitive to phylloxera, a weevil that was brought to Europe from America in 1863. As the vines had previously grown on their own roots, the vineyards died out in following decades. From the south of France, where it first appeared, phylloxera quickly spread to most wine-growing countries (Bates et al., 2001; Marković, 2023).

The North American grapevine and its hybrids and hybrids of the American-European grapevine were used as rootstock for grafting noble grape varieties due to their high resistance to this parasite. A large number of different rootstocks have been used in the world and in our country (Provost et al., 2021).

Many have been replaced by better rootstocks, of which a number of the best rootstocks are used for grafting (Žunić and Garić, 2010).

Depending on the agrobiological properties of the soil and the agrobiological properties of the variety, the grapevine rootstock is selected that production requirements based on its properties (Reynolds et al., 2001; Nakalamić and Marković, 2009). Rootstocks can influence a number of agrobiological characteristics of the grafted variety. Since the rootstock absorbs water and minerals, it affects the growth, vigor and phenology of the grafted variety (Hoover et al., 2004; Somkuwar et al., 2014; Sera et al., 2014). Rootstock can prolong the vegetation period, while cause the grapes to ripen earlier (Kaplan et al., 2018).

MATERIALS AND METHODS

The tests were carried out at Krnjevo wine sub region (alt. 220 m a.s.l., lat. 44º 25' 47" N and long. 21º 02' 14" E) on Cabernet Sauvignon clone 15, which was grafted onto two rootstocks SO4 and 1103 Paulsen. The vineyard had a planting density of 4630 vines per hectare, spaced 0.9 m within and 2.4 m between east-west oriented rows. Guyot training system was

The research included examination of the phenological characteristics of the clones (Lorenz et al., 1994), the fertility, the mechanical composition of the clusters and berries and the chemical quality of the grape juice. The fertility is represented by the coefficients of potential, relative and absolute fertility. The grapes were harvested at full ripeness (phenolic ripeness) and analysed in the laboratory of the Department of Viticulture of the Faculty of Agriculture University of Belgrade.

Mechanical analysis of grapes (bunches) and berries was performed according to the methods of Marković and Przić (2020). The grapes were measured in terms of their weight, length and width. The number of berries per bunch was also determined and the mass of berries per bunch and the mass of stems were measured on an analytical balance. From each sample, 100 representative berries were selected and after measuring the mass of the berries, the berry skin and seeds were separated. Of the chemical parameters of the grape juice composition (must), sugar content (%), total acidity (g/l) and pH were determined. The sugar content was determined by physico-chemical methods using the Oeshle must balance, the values were calculated using the Dujardin-Salleron tables. The total acidity was determined by titration with n/4 NaOH and the pH with a pH metre.

RESULTS AND DISCUSSIONS

The phenological analysis of the Cabernet Sauvignon variety on the rootstocks examined did not reveal any variation in the length of the phenophases. The beginning of bleeding was recorded on 24.03., budburst on 13.04., flowering on 29.05., *veraison* on 01.08. and harvest on 01.10. It took 20 days from bleeding to budburst, 45 days from budburst to flowering, 12 days from the beginning to the end of flowering, 53 days from the end of flowering to *veraison* and 62 days from *veraison* to harvest. An average of 192 days passed from the budburst to harvest. The results of the observation are shown in Table 1.

According to Pržić (2015), the duration of the phenophases can vary from bleeding to full ripeness of the grapes. Based on phenological observations at the Oplenac site, Pržić (2015) determined the following average phenophase dates for the Cabernet Sauvignon variety: beginnig of bleeding on March 26, beginning of budburston April 14, beginning of flowering on June 3, *veraison* on August 20, full ripening on September 20. The average duration of the phenophases was expressed in days: from the beginng of bleeding to budburst 20 days, from to flowering 51 days, from the beginning to the end of flowering 13 days, from the end of flowering to

veraison 66 days, from veraison to full maturity 67 days. An average of 217 days elapsed from the budburst to full maturity.

Table 1. Phenological observations

Phenophases	Beginning	End	Duration (days)
Bleeding (Cod. 00-03)	24.03.	10.04.	18
Budburst (Cod. 05-08)	13.04.	21.04.	9
Shoot growing (Cod. 11-19)	28.04.		
Flowering (Cod. 60-69)	29.05.	09.06.	12
Developing of berries (Cod. 71-79)	15.06.		
Harvest	*Veraison* (Cod. 81-83)	01.08	62
	Harvest (Cod. 85-89)	01.10	
Days from bleeding to harvest			192

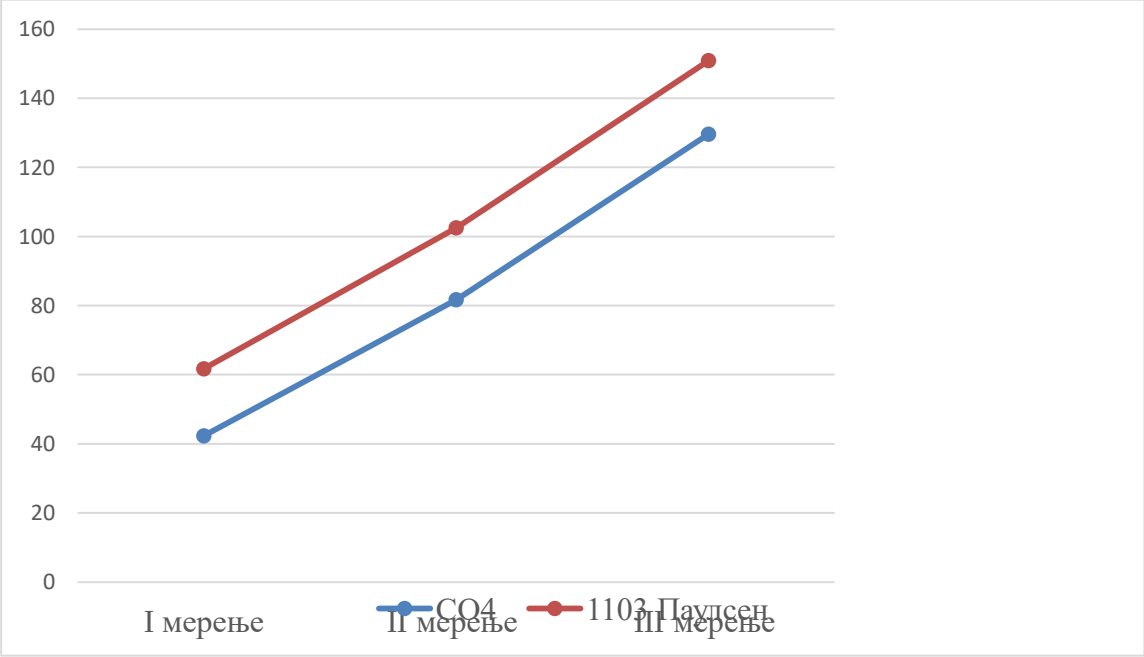
The vegetative growth of the shoots was determined on three dates at 14-day intervals. The first measurement was carried out on May 25, the second on June 8, and the third on June 22.

Table 2. Average values of shoot growth (in cm)

Nº of trunk	I measurement		II measurement		III measurement	
	SO4	1103 Paulsen	SO4	1103 Paulsen	SO4	1103 Paulsen
1	36.0	48.3	86.3	84.9	115.8	143.7
2	37.5	52.0	89.1	99.3	124.5	135.6
3	40.0	53.8	87.9	101.2	129.6	139.2
4	40.3	54.7	79.0	96.4	128.5	141.5
5	30.8	43.1	65.3	79.4	114.7	139.7
6	44.3	58.8	78.6	117.9	134.8	164.2
7	40.5	79.3	86.0	125.6	131.4	179.6
8	44.1	68.4	88.8	120.6	134.7	153.6
9	25.8	43.2	59.8	85.2	98.5	118.6
10	50.6	64.9	85.9	97.8	137.8	154.6
11	44.1	58.2	75.9	97.3	128.9	134.6
12	27.1	45.4	67.9	92.6	117.9	132.7
13	34.4	52.6	56.9	94.7	82.8	139.4
14	61.3	77.4	92.1	113.2	153.7	169.4
15	46.6	67.4	85.6	98.6	137.6	145.3
16	39.5	58.8	79.0	95.3	132.8	139.9
17	51.1	77.9	93.1	116.8	152.3	171.3
18	48.5	76.8	77.9	106.2	142.7	172.5
19	49.4	77.9	95.3	109.3	139.2	174.2
20	54.1	74.6	104.3	116.9	152.9	169.3
Average	**42.3**	**61.7**	**81.7**	**102.5**	**129.6**	**150.9**

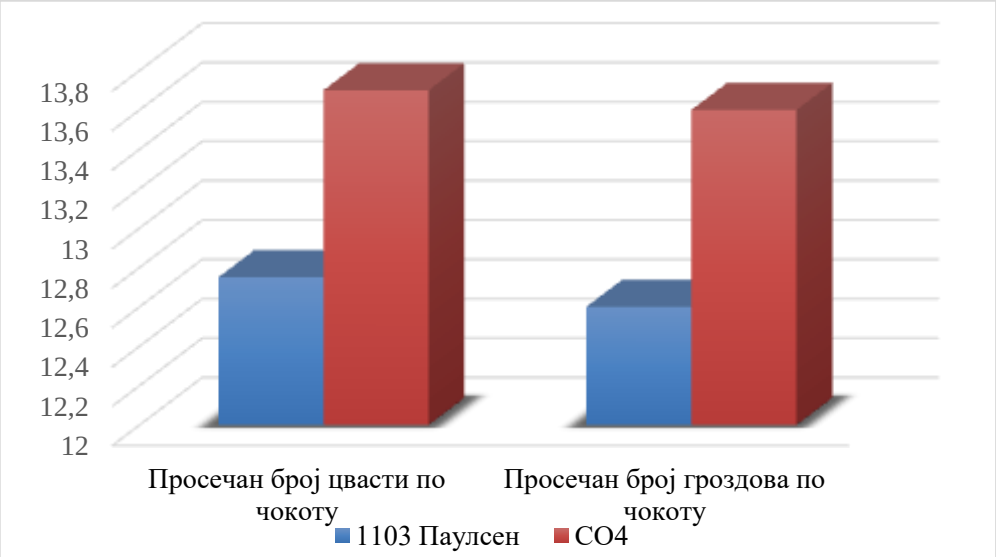
In all three measurements, higher shoot growth was observed on rootstock 1103 Paulsen. The largest measured shoot length was 179.6 cm, while the smallest measured shoot length was 118.6 cm. The average length of the shoots was 150.9 cm. On rootstock SO4, the largest measured shoot length was 152.9 cm and the smallest measured shoot length was 82.8 cm. The average length of the shoots was 129.6 cm. There was a very significant difference in the average shoot growth values between these two rootstocks.

According to the study by Marković (2001), Cabernet Sauvignon shows variability in shoot growth depending on the rootstock on which it is grafted. In the trial, Cabernet Sauvignon was grafted onto three rootstocks: SO4, K 5BB and Š 41B. The longest shoot length was measured on rootstock SO4 (178.1 cm), then on rootstock K 5BB (168.4 cm) and finally on rootstock Š 41B (161.6 cm).



Graph 1. Average shoot growth (in cm)

Fertility was monitored by counting the inflorescences at the beginning and end of the flowering phenophase. On rootstock SO4 were 273 inflorescences developed and 255 inflorescences on rootstock 1103 Paulsen. The differences in the number of inflorescences developed are shown in graph 2.



Graph 2. Average number of developed inflorescences and bunches

According to a study (Nuzzo and Mathews, 2006), Cabernet Sauvignon on the SO4 rootstock produces an average of 19 bunches, while on the 1103 Paulsen rootstock the average number of bunches is 10. The research confirmed this trend: more clusters were formed on rootstock

SO4 (13.7) than on rootstock 1103 Paulsen (12.6).

The fertility coefficients of the Cabernet Sauvignon variety on both rootstocks had higher values compared to literature reports (Žunić, Garić 2017), which vary in the interval of 1.1-1.4. The rootstock SO4 had higher fertility coefficients (KPF – 1.71; KRF – 1.71; KAF – 1.83) than the rootstock 1103 Paulsen (KPF – 1.59; KRF – 1.59; KAF – 1.7).

Table 3. Coefficients of potential, relative and absolute fertility

Coefficients	CO4	1103 Paulsen
Coefficients of potential fertility (KPF)	1.71	1.59
Coefficients of relative fertility (KRF)	1.71	1.59
Coefficients of absolute fertility (KAF)	1.83	1.7

The yield of Cabernet Sauvignon grapes grafted on rootstock SO4 was between 1.100 and 3.190 kg/trunk, and on rootstock 1103 Paulsen between 1.275 and 2.205 kg/trunk. According to a study by Nuzzo and Mathews (2006), the yield per shoot was 1 kg for rootstock SO4 and 1.5 kg for rootstock 1103 Paulsen, which shows that the rootstocks achieved better results under the conditions of the Krnjevo wine sub region.

The mechanical analysis included indicators of bunches and berry composition. The data are presented in Table 4.

Table 4. Parameters of mechanical analysis of bunches and berries

Parameters		Average	
		SO4	1103 Paulsen
Bunch mass (g)		143.1	175.4
Bunch length (cm)		11.1	12.1
Bunch width (cm)		6.2	7.0
The number of berries in a bunch		142.3	151.6
Mass of all berries in bunch (g)		137.2	166.2
Weight of 100 berries (g)		117.0	133.0
Weight of the skins of 100 berries (g)		10.1	11.9
Seed weight of 100 berries (g)		5.8	7.2
Number of seeds per 100 berries (g)		180	194
Mass of bunch stem(g)		3.7	5.5
Weight of 100 seeds (g)		3.1	3.7
Berry dimensions	Length (mm)	11.6	12.6
	Width (mm)	11.8	12.2

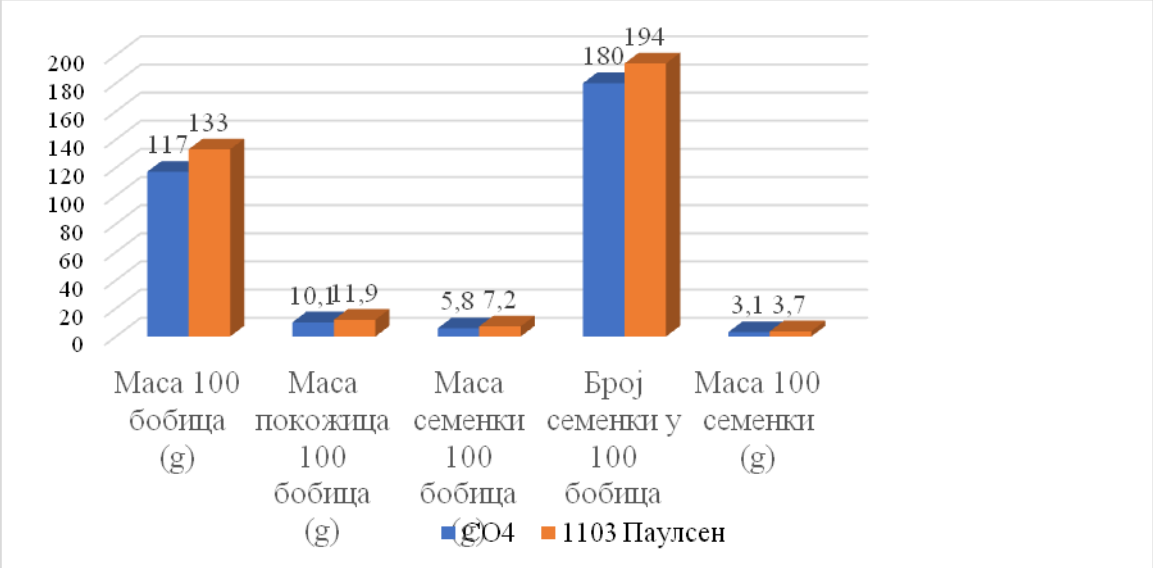
A higher average cluster weight (175.4 g) and a higher average number of berries in the bunch (151.6) were measured on the 1103 Paulsen vine rootstock. The average mass of berries in a bunch was higher for the 1103 Paulsen rootstock, at 166.2 g, compared to SO4 (137.2 g). The mass of berries in a cluster is significantly higher in the examined rootstocks than in the literature by Žunić and Garić (2017), where the mass of a cluster varies between 70 and 90 g. The number of berries in a bunch was significantly higher in the examined rootstocks (Table 4) than in the literature by Žunić and Garić (2017), who state that the number of berries can vary between 60and 75.

According to Marković et al. (2011), the weight of the bunch stem for

ISV FV 5 and ISV FV 6 clones of the Cabernet Sauvignon variety was 4 g and 4.6 g respectively. In relation to these data, the mass of bunch stem was lower in rootstock SO4 and amounted to 3.7 g and 5.5 g in 1103 Paulsen. A significant difference between these two rootstocks was statistically confirmed.

For rootstock SO4, the average cluster length was 11.1 cm and the average berry length was 11.6 mm, while the average cluster width was 6.2 cm and the berry width was 11.8 mm. The Cabernet Sauvignon grapes on the 1103 Paulsen rootstock had an average cluster length of 12.1 cm and a berry length of 12.6 mm, while the average cluster width was 7 cm and the berry width 12.2 mm.

Graphic number 8 shows the variation of the parameters of the mechanical analysis of the berries for both rootstocks. Significantly higher values were determined for the mass of 100 berries, the mass of the skin of 100 berries, the mass of the seeds of 100 berries, the mass of 100 seeds and the number of seeds in 100 berries on rootstock 1103 Paulsen. According to Yung et al. (2019), the mass of 100 berries on rootstock SO4 was 130 g, which is higher than in the trial.



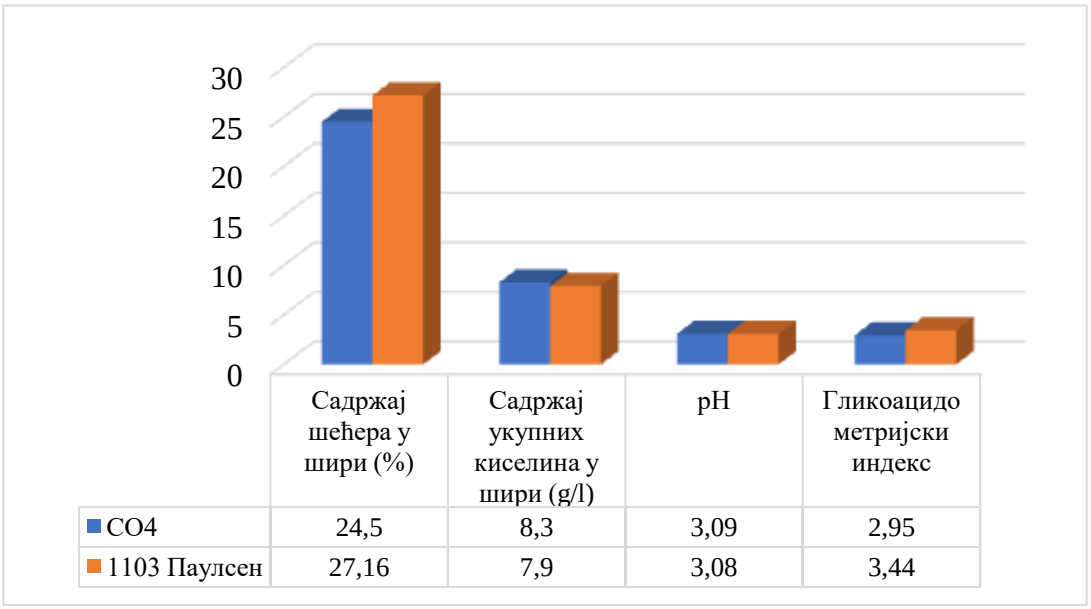
Graph 3: Mechanical composition of the berries on SO4 and 1103 Paulsen rootstocks

On rootstock 1103 Paulsen, a lower percentage of skin on the bunch (6.80%) was observed compared to SO4 (7.06%). The higher percentage of skin in black varieties is an important characteristic due to the anthocyanin content, which increases the oenological potential of the variety (Klimek et al., 2022). The results of the structural indicators of the cluster are presented in Table 5.

Table 5. Structural indicators of the cluster

Parameters	Rootstock	
	SO4	1103 Paulsen
Bunch stem percentage (%)	2.58	3.15
Berry skin (%)	7.1	6.80
Seed percentage (%)	4.06	4.16
Mesocarpe percentage (%)	92.9	93.2
Hard residue	13.7	14.1
Cluster structural indicator	6.78	6.61

Graph number 4 shows the results of the chemical composition of grape juice-must. On rootstock SO4, the accumulated sugar content was 24.5%, while the glycoacidometric index was 2.9. A higher sugar content (27.1 %) was found on rootstock 1103 Paulsen, while the total acid content was lower (7.9 g/l) compared to rootstock SO4.



	Садржај шећера у шири (%)	Садржај укупних киселина у шири (g/l)	pH	Гликоацидо метријски индекс
CO4	24,5	8,3	3,09	2,95
1103 Паулсен	27,16	7,9	3,08	3,44

Graph 4. Chemical composition of the grape juice

CONCLUSIONS

In the phenological analysis of the Cabernet Sauvignon variety, no deviation in the length of the phenophases was observed on the rootstocks examined. It took 192 days from bleeding to full maturity.

Vegetative growth was determined by measurements in three terms, with higher shoot growth being observed on rootstock 1103 Paulsen. The largest shoot length measured was 179.6 cm, while the smallest measured shoot length was 118.6 cm. The Cabernet Sauvignon grafted onto rootstock SO4 grew less vigorously, with the highest measured shoot length at the third measurement being 152.9 cm and the smallest measured shoot length 82.8 cm.

The Cabernet Sauvignon developed 273 inflorescences on rootstock SO4 and 255 inflorescences on rootstock 1103 Paulsen. The grape yield on rootstock SO4 was between 1,100 and 3,190 kg/trunk, while it was lower on rootstock 1103 Paulsen at 1,275 to 2,205 kg/trunk.

The mechanical analysis of bunches and berries on rootstock 1103 Paulsen showed a higher average mass of bunches of 175.4 g and a higher average number of berries in a bunch of 151.6 g. In addition, a lower proportion of skin in the bunch (6.80%) was found compared to SO4 (7.06%). The higher percentage of berry skin in black varieties is an important characteristic due to the content of anthocyanins, which increase the oenological potential of the variety. For the mass of 100 berries, the mass of the skin of 100 berries, the mass of the seeds of 100 berries, the mass of 100 seeds and the number of seeds in 100 berries, significantly higher values were determined on rootstock 1103 Paulsen.

The analysis of the chemical composition showed lower values of the accumulated sugar (24.5 %) and the glycoacidometric index (2.9) on rootstock

SO4 compared to rootstock 1103 Paulsen.

ACKNOWLEDGEMENTS

The research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under project number 451-03-47/2023-01/200116.

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