Popovic, T., Raicevic, D., Pajović-Šćepanović, R. (2025). Yield and quality of grapes from Montenegrin seedless varieties in the Podgorica subregion. Agriculture and Forestry, 71 (1): 159-168. https://doi:10.17707/AgricultForest.71.1.12

DOI:10.17707/AgricultForest.71.1.12

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YIELD AND QUALITY OF GRAPES FROM MONTENEGRIN SEEDLESS VARIETIES IN THE PODGORICA SUBREGION

SUMMARY

This study presents the results of research on the agrobiological, economic and technological characteristics of Montenegrin seedless grapevine varieties grown in the ampelographic collection of the Biotechnical Faculty in Podgorica. The research was conducted in 2020–2021 period. The highest grape yield and cluster weight were recorded in the variety PIT 15 (2.23 kg/m² and 428 g), while the lowest values were observed in the variety Razaklija Besjemena (1.45 kg/m² and 225 g). The variety PIT 15 also exhibited the highest average berry weight (3.23 g), whereas the smallest berries were measured in the variety Podgorička Besjemena (2.64 g). The sugar content in grape juice varied significantly among the studied varieties. The highest sugar levels were recorded in varieties PIT 14 (16.2%) and Podgorička Besjemena (16.1%), while the lowest sugar levels were observed in PIT 15 and Razaklija Besjemena (15.3%). The total acidity of the grape juice was generally low during both years of the study, which is characteristic of Mediterranean climatic conditions such as those in Montenegro. The highest average acidity over the two years was found in the variety PIT 14 (5.40 g/L), while the lowest acidity was recorded in PIT 15 (4.70 g/L). Statistical analysis revealed that the differences among all the parameters studied were highly significant.

Keywords: grapevine, seedless varieties, yield, cluster weight, grape quality

INTRODUCTION

Global grape production reaches approximately 75 million tons annually, making grapevines one of the most widely cultivated fruit crops in the world (Akkurt, 2019; Kaya, 2020; Boztepe, 2023). Of the total grape production, the majority is used for winemaking, while a smaller portion is consumed fresh, dried, or processed into various products (Bešlić, 2019; Izcara, 2021).

The technology for producing table grapes for large markets and export has been nearly perfected. This is increasingly significant given rising living

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Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Recieved:08/12/2024 *Accepted:19/03/2025*

standards and growing consumer expectations regarding the nutritional content and quality of grapes (Al Saif, 2022). Today, consumers have access to fresh grapes of impeccable appearance year-round, sourced from various countries around the world.

In recent decades, seedless grape varieties have become highly popular and valued by consumers, gradually replacing seeded varieties (Royo et al., 2018). The primary use of seedless grape varieties has historically been for producing raisins, but their importance as table grapes for fresh consumption has grown significantly in recent years (Matijašević, 2021). However, seedless varieties also have certain limitations, including small berry size, fragile pedicels, and a firm attachment of berries to the stem. To produce high-quality table grapes with larger berries from these varieties, special practices are employed, such as cane or trunk girdling, treatment with growth regulators, and other methods (Cindrić et al., 2000, 2003; Korać, 1998; Dimovska et al., 2014).

The world's largest producers of raisins are California, contributing approximately 30% of global raisin production, followed by Turkey (23%), Greece (21%), Australia (10%), and Iran (6%) (Cindrić et al., 2019; Bešlić, 2019). Smaller quantities of raisins are also produced in Argentina, Chile, Italy, and Morocco.

The Podgorica wine-growing region, characterized by its Mediterranean climate, provides ideal conditions for cultivating table grape varieties of all ripening epochs (Popović, 2024). However, despite favorable agroecological conditions, table grape production is significantly less prevalent compared to wine grape varieties. Of the total vineyard area in Montenegro (2,800 ha), only 7.89% is dedicated to table grape varieties (Rejonizacija). Furthermore, seeded table grape varieties dominate these areas, while seedless varieties remain underrepresented and are mostly studied in ampelographic collections.

At the Experimental Field of the Biotechnical Faculty in Podgorica, several seedless grapevine varieties of diverse origins are cultivated, including five seedless varieties developed at the Agricultural, later Biotechnical Institute in Podgorica.

The aim of this study was to examine and present in detail the agrobiological and economic-technological characteristics of these five seedless grapevine varieties (Podgorička Besjemena, Razaklija Besjemena, PIT 14, PIT 15, PIT 16) to provide more data to science and practice, enabling better evaluation, more intensive cultivation, and broader dissemination of these varieties in the viticultural regions of Montenegro and beyond.

MATERIAL AND METHOD

Vineyard location

The study of agrobiological, economic and technological characteristics of Montenegrin seedless grapevine varieties was conducted during the 2020 and 2021 growing seasons. The research was performed in the Collection Vineyard of the Biotechnical Faculty in Podgorica (42° 26′ 78″ N, 19° 12′ 57″ E), established in 2005 with a planting distance of 2.4 m between rows and 1 m within row. The vines were trained as double-arm horizontal cordons with a trunk height of approximately 80 cm. Mixed pruning was applied. The experimental vineyard

was irrigated using a drip irrigation system throughout the study. The trials included 75 vines in total, organized into three replications with five vines per replication.

Description of Studied Varieties

The following varieties were evaluated: Podgorička Besjemena (PB), Razaklija Besjemena (RB), PIT 14, PIT 15, and PIT 16.

Podgorička Besjemena was developed by crossing Bijeli Čauš with Perlette . It produces medium-sized clusters and berries with a light green to golden-yellow skin and ripens in early August (Figure 1)

Figure 1. Podgorička besjemena

–Razaklija Besjemena was created by crossing Razaklija with Sultanina. It inherited the cluster and berry shape of Razaklija and seedlessness from Sultanina. Ripens in late August.

–PIT 14 is an early ripening seedless variety (mid-August) resulting from the cross of Bijeli Čauš and Perlette. It features medium-sized clusters and berries with a yellow-green color and muscat flavor.

–PIT 15 is a late-season variety that ripens in early September. It was developed by crossing Razaklija and Sultanina to create a high-yielding seedless variety with loose, large clusters and medium-sized greenish-yellow berries.

–PIT 16 was developed from a cross between Bijeli Čauš and Sultanina. It is characterized by large, loose clusters and oval-shaped greenish-yellow berries with an aromatic and pleasant flavor. This high-yielding variety also ripens in early September.

Evaluation of Agrobiological Parameters and Analytical Methods Used in the Study

During the two-year study, the following parameters were assessed: the number of clusters, grape yield (kg/m²), cluster and berry mass (g), cluster and berry length and width (cm for clusters, mm for berries), and sugar content (%) and total acidity (g/L) in grape juice. Grape yield was determined by weighing the harvested grapes, while cluster mass was calculated based on the yield from five vines and the total number of clusters. After harvest, the length and width of clusters and berries, as well as the average berry mass, were measured. Sugar content in grape juice was determined areometrically with Oechsle hydrometer. Total acidity in grape juice was measured through neutralization of all acids and their salts using a 0.1N NaOH solution, with bromothymol blue as the pH indicator.

The collected data were analyzed using analysis of variance (ANOVA) for a completely randomized block design. The significance of differences was determined using the LSD test.

Climate Conditions at the Experimental Site

Climatic analysis for the Lješkopolje region was based on data from the meteorological station in Podgorica. The average annual and growing season air temperatures during the study years were relatively consistent (Figure 2). The average annual and growing season air temperatures in 2020 were slightly higher (17.2°C and 22.4°C) compared to 2021, when they measured 17.0°C and 22.3°C, respectively. The sum of effective temperatures was notably high (2669°C and 2636°C), classifying this wine-growing region into Zone V according to Winkler's classification, indicating a very warm climate.

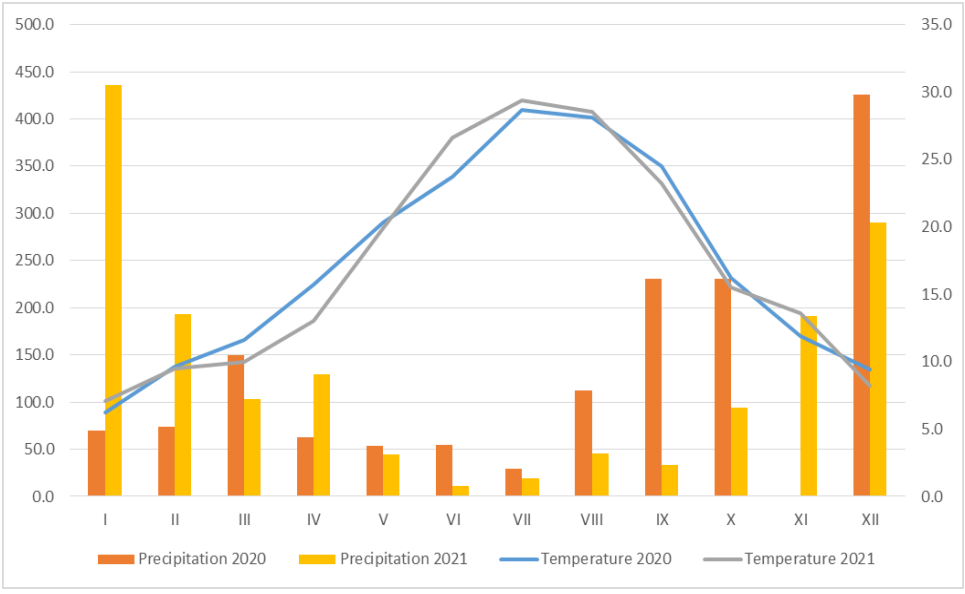

Figure 2. Average monthly precipitation and temperatures during the 2020-2021 period.

The annual precipitation sum in 2021 was higher, resulting in 1590.5 l/m². However, during the growing season, more precipitation occurred in 2020 (775.0 l/m²). Notably, the period from August to September 2020 experienced particularly heavy rainfall, with 112 l/m² in August and 231 l/m² in September.

RESULTS AND DISCUSSION

Based on the data in Table 1, it can be observed that the number of clusters in the studied period ranged from 13 to 15.8 for the 2020 harvest and from 12 to 15.1 for the 2021 harvest. In terms of average values for the two studied harvests, the highest number of clusters was found on the Razaklija Besjemena vines (15.5), while the lowest number was observed in the PIT 15 variety (12.5). Statistical analysis revealed a significant difference in the number of clusters between Razaklija Besjemena and all other studied varieties.

The cluster size, as a very important parameter for the quality of table grapes, was determined based on the average mass, length, and width of the cluster. Analyzing the two-year average values of cluster mass, it can be observed that the largest cluster mass was found in the varieties PIT 15 (428 g) and PIT 16 (377 g), while the smallest mass was recorded for the Razaklija besjemena variety (225 g). Statistical analysis showed that the PIT 15 and PIT 16 varieties had significantly higher cluster mass compared to all other studied varieties. A significant difference in cluster mass was also observed between the Podgorička besjemena and PIT 14 varieties when compared to the Razaklija besjemena variety. The average cluster mass for all studied varieties was higher in the first year of research (331g) compared to the second year (307g), which is likely due to the higher precipitation amounts during the May-July period of 2020, when the berries were growing intensively. These results align with those of Popović et al. (2013), who found that the cluster mass of the Vranac variety in the Podgorica wine region was also higher in climate-favorable years. The average cluster mass of the PIT 15 variety in these studies was in line with the values reported by Ulićević et al. (1991) under the same agroecological conditions, while the cluster mass of the PIT 14 and PIT 16 varieties was slightly lower than the results from their research.

Table 1. Cluster weight and grape yield of studied varieties

Variety	Number of clusters		Average	Cluster weight (g)		Average	Grape yield (kg/vine)		Average
	2020	2021		2020	2021		2020	2021	
PB	14.0	13.0	13.5	314	292	303	1.83	1.58	1.70
RB	15.8	15.1	15.5	239	211	225	1.57	1.33	1.45
PIT 14	14.6	13.5	14.0	275	248	261	1.68	1.40	1.54
PIT 15	13.0	12.0	12.5	435	420	428	2.36	2.10	2.23
PIT 16	14.0	13.0	13.5	393	362	377	2.29	1.96	2.12
Average	14.2	13.6	13.9	331	307	319	2.06	1.67	1.81

Parameter	Number of clusters		Cluster weight		Grape yield	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2020-2021	0.628	0.872	16.998	23.577	0.174	0.241

Grape yield per unit area, as an absolute indicator of variety productivity, depends on various factors such as the genetic potential of the variety, production technology, vineyard age, climatic conditions, and the health of the vines (Melo & Ribeiro, 2011; Popović, 2012). Based on the results in Table 1, significant variations in grape yields were observed between the studied varieties and the years of research. The yields in the studied years ranged from 1.57 kg/m² to 2.36 kg/m² in 2020 and from 1.33 kg/m² to 2.10 kg/m² in 2021. The lowest grape yields over the two-year average were observed for the Razaklija besjemena and PIT 14 varieties (1.45 kg/m² and 1.54 kg/m²), while the highest yields were recorded for the PIT 15 variety (2.23 kg/m²) and PIT 16 variety (2.12 kg/m²). Statistical analysis revealed that the grape yield for the PIT 15 and PIT 16 varieties was significantly higher over the two-year average compared to all other studied varieties, while the yield for the Podgorička besjemena variety was significantly higher only compared to the Razaklija besjemena variety. Other observed differences in yields were not statistically significant. The yields achieved in the studied years were similar to those reported by other authors for the studied varieties under the same agroecological conditions (Ulićević, 1991; Pejović, 1997, 2002).

Regarding the length and width of clusters for the studied varieties (Table 2), it was notable that the PIT 16 variety had the largest cluster length (20.6 cm) and width (12.9 cm), while the Razaklija besjemena variety had the smallest cluster length (16.0 cm) and width (10.6 cm).

Table 2. Length and width of cluster of studied varieties

Variety	**Cluster length (cm)**		**Average**	**Cluster width (cm)**		**Average**
	2020	2021		2020	2021	
PB	17.2	16.5	16.8	13.0	12.7	12.8
RB	16.3	15.8	16.0	11.3	9.9	10.6
PIT 14	16.1	15.9	16.0	11.6	10.6	11.1
PIT 15	20.2	19.1	19.6	12.3	11.8	12.0
PIT 16	22.3	19.0	20.6	13.5	12.3	12.9
Average	18.2	17.5	17.8	12.0	11.8	11.9

Parameter	**Cluster length**		**Cluster width**	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2020-2021	0.743	1.030	0.604	0.839

A statistically significant difference in cluster length was observed between the PIT 16 variety and all other studied varieties. Additionally, a significant difference in cluster length was noted between the Podgorička besjemena variety and the Razaklija besjemena and PIT 14 varieties. The cluster width was significantly larger in the PIT 16 and Podgorička besjemena varieties compared to all other studied varieties, and in the PIT 15 variety, it was larger only compared to the

Razaklija besjemena and PIT 14 varieties. Similar results regarding the cluster length and width of these varieties were obtained by Pejović (1997; 2002) under the agroecological conditions of the Podgorica subregion.

The data presented in Table 3, indicate that the berries of the PIT 15 variety had the greatest length (20.50 mm), while the shortest berry length was observed in the Podgorička besjemena variety (15.73 mm). Statistical analysis revealed that the PIT 15 and PIT 16 varieties had significantly larger berry lengths compared to all other varieties, while the PIT 14 and Razaklija besjemena varieties had significantly larger berry lengths only compared to the Podgorička besjemena variety.

As for the berry width, the largest berries were found in the PIT 14 variety (17.25 mm), while the smallest were in the Podgorička besjemena variety (13.38 mm). The difference in berry width was statistically significantly larger between the PIT 14, PIT 15, and PIT 16 varieties compared to the Razaklija besjemena and Podgorička besjemena varieties, as well as between the Razaklija besjemena variety and the Podgorička besjemena variety.

Table 3. Physical characteristics studied varieties

Variety	Berry length (mm)		Average	Berry width (mm)		Average	Berry weight (g)		Average
	2020	2021		2020	2021		2020	2021	
PB	16.33	15.13	15.73	13.70	13.07	13.38	2.72	2.57	2.64
RB	17.50	16.15	16.82	15.30	14.35	14.82	2.83	2.65	2.74
PIT 14	17.70	16.90	17.30	17.30	17.21	17.25	2.86	2.73	2.79
PIT 15	20.70	20.30	20.50	16.62	16.26	16.44	3.32	3.15	3.23
PIT 16	20.38	20.01	20.19	16.40	16.00	16.20	2.88	2.67	2.77
Average	18.52	17.69	18.10	15.87	15.37	15.62	2.92	2.75	2.84

Parameter	**Berry length**		**Berry width**		**Berry weight**	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01

For all GNSS measurements (static/rapid static), the data recording interval was set at 1 second and the elevation mask was utilized as 7.5°. The evaluation of static and rapid static GNSS data was conducted using Topcon Magnet Tools 8.1.0 commercial software, and precise positioning was achieved through the utilization of precision ephemeris and Final IGS products. The objective of this experiment was to compare the accuracy of different measurement techniques and to analyses methods to enhance positioning accuracy in forest areas. The experiments were conducted in selected forest areas in the Davutpaşa Campus region of Yıldız Technical University.

Two different geometries were selected for this purpose, where the angle (ɣ) was small (Figure 3) and around 100g (Figure 4). Initially, on 3 October 2023, points P1 and P2 were established in proximity to test site 1, while P5 and P6 were established in proximity to test site 2. GNSS measurements were then performed on these points in static measurement mode for duration of 2 hours, after which their coordinates were calculated.

Table 4. Chemical characteristics of studied varieties

Variety	Sugar content		Average	Acid content		Average
	2020	2021		2020	2021	
PB	15.7	16.5	16.1	5.5	5.0	5.2
RB	14.9	15.7	15.3	5.4	4.5	4.9
PIT 14	16.0	16.5	16.2	5.8	5.0	5.4
PIT15	14.7	16.0	15.3	4.3	5.1	4.7
PIT16	15.2	15.5	15.7	5.5	5.2	5.3
Average	15.3	16.0	15.7	5.2	5.1	5.1

Parameter	Sugar content		Acid content	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01
2020-2021	0.459	0.637	0.345	0.479

A significant difference was also found between the PIT 16 and Razaklija besjemena varieties. The sugar content in the juice was higher in all examined varieties in 2021, which is a direct consequence of the different meteorological conditions in the years the study was conducted, particularly the lower rainfall during the 2021 growing season.

The acidity content in grape juice is an important indicator of grape quality, as it affects the taste and harmony of the fruit (Popović, 2020). The highest acidity was found in the PIT 14 (5.40 g/l) and PIT 16 (5.30 g/l) varieties, while the lowest acidity was in the PIT 15 variety (4.70 g/l). Statistical analysis revealed that the PIT 14, PIT 16, and Podgorička besjemena varieties had significantly higher acidity content compared to the PIT 15 variety. Additionally, a significant difference was found between the PIT 14 and PIT 16 varieties compared to the Razaklija besjemena variety. The results of these two-year investigations showed that the acidity of grape juice was low during both years of the study, which is typical for Mediterranean climates such as that of Montenegro (Pajović, 2014).

CONCLUSION

Based on the conducted research, the following conclusions can be drawn:

–The average grape yield over the two-year period was highest for the PIT 15 variety (2.23 kg/m²), while the lowest yield was observed for the Razaklija besjemena variety (1.45 kg/m²).

–The number of clusters varied significantly among the tested varieties, ranging from 12.5 for PIT 15 to 15.5 for Razaklija besjemena.

–The average cluster mass ranged from 225 to 428 g, with the highest cluster mass found in the PIT 15 variety and the lowest in Razaklija besjemena.

–The average berry mass, length, and width were largest in the PIT 15 variety (3.23 g), while the Podgorička besjemena variety had the smallest berries (2.64 g).

–In the two-year average, the highest sugar content was found in PIT 14 (16.2%) and Podgorička besjemena (16.1%), while the lowest sugar content was in PIT 15 and Razaklija besjemena (15.30%). Sugar content was higher in all

examined varieties in 2021, due to lower rainfall during the growing season of that year.

–The acidity content in the juice was characteristic for the varieties studied in the Podgorica vine region, with the highest acidity (5.4 g/l) found in PIT 14.

–All studied varieties, based on the two-year results, deserve greater attention and representation in the vineyards of Montenegro and beyond.

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