Darko JAKŠIĆ[*], Pierfederico LA NOTTE[**], Pamela Beatrice GIANNINI[***], Veljko PEROVIĆ[§], Alessandra CAGNAZZO[***]

MONTENEGRIN VRANAC VINE VARIETY IN THE MOST EASTERN POINT OF THE VRANAC CULTIVATION AREA — KNJAŽEVAC WINE-GROWING REGION (SERBIA)

Abstract: For Montenegrin vine variety Vranac there is the opinion that its high quality wines can be produced mostly in Mediterranean climates and there is no possibility of over-spreading of this variety out of warmer areas. The most eastern point of the Vranac cultivation area is the Knjaževac wine-growing region (Serbia), the Potrkanje locality, which is characterized by colder climates (B climate Winkler zone) and an average vineyard altitude of 306 m. It is in such environmental conditions that wine from this variety are regularly assessed in the category of best quality wines "vrhunsko K. G. P. K. vino" with purple stamps of quality and origin within the "PDO/PGI" system of geographical indications of Serbia.

In this paper, a detailed wine analysis was carried out in Italy using highly sophisticated laboratory equipment, where wine from the Vranac variety from the Knjaževac wine-growing region (Potrkanje locality) from the 2011, 2013 and 2015 vintage was analyzed. Laboratory analysis of quality parameters, including total anthocyanins, intensity of color, color tone of wine etc., characterization of the quality and specificity of the wine were performed. In this paper certain positive characteristics of quality of Vranac variety wine are determined, regardless of the fact that the vineyards are in completely different climatic and soil conditions in relation to the original conditions of Montenegro.

Key words: *Vranac vine variety, wine quality parameters, Knjaževac wine-growing region*

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[*] Center for Viticulture and Oenology, Belgrade, Serbia

[**] Institute of Vegetal Virology (IVV), Bari, Italy

[***] Center for Research and Training in Agriculture "Basile — Caramia", Bari, Italy

[§] Institute for Biological Research "Siniša Stanković", University of Belgrade, Belgrade, Serbia

INTRODUCTION

Earliest cultivation of the Vranac variety in Serbian wine-growing geographical areas has not been determined, but it is not ruled out that this autochthonous Montenegrin variety [28] spread from Crmnica wine-growing subregion (Montenegro) to some wine-growing areas in Serbia before the Second World War. After the Second World War, due to intensive rising of vineyards on large surfaces, and also due to the excellent quality of grapes and wines from the Vranac variety, this variety began to spread and vine seedlings started being produced in the Trstenik wine-growing subregion. Spreading of the Vranac variety occurred mostly in the hilly wine-growing areas in central Serbia, but it was also grown in the north of the country, in the western part of the Srem wine-growing region.

The easternmost point of cultivation of the Vranac variety in Serbia and thereby the easternmost point of current cultivation of this entire variety is the Knjaževac wine-growing region, Potrkanje locality. Potrkanje is at the same time one of the four wine-growing subregions of the Knjaževac wine-growing region [8]. The Knjaževac region, having the surface of 177.805,70 [6], is spread along the Timok River valley surrounded by mountains in the east of Serbia, spreading in the north-south direction, and the Potrkanje wine-growing subregion includes the southernmost parts of the region, mostly hilly terrains on either side of the Timor River. Although this wine-growing region is characterized by colder continental climate with the average vegetative temperature of 16.8 °C as measured in the Knjaževac meteorological station [18], this variety is showing excellent results in conditions prevailing in the Potrkanje locality. It is precisely because of the high quality of wines of the Vranac variety and characteristics of these wines that the red wine type "Knjaževac" Vranac was registered within the Protected Designation of Origin (PDO) "Knjaževac" [10].

Considering that there is a generally opinion that the Vranac variety provides the best quality of wines in general environmental conditions of its origin (Mediterranean climate), while on the other hand wines of this variety with the "Knjaževac" PDO regularly receive the highest marks for quality in the strict system of geographical indications in Serbia, the aim of this paper is to examine quality parameters of wines of this variety, some of which have not been thoroughly examined thus far.

MATERIALS AND METHODS

STUDY AREA

Vineyards within the Knjaževac wine-growing region were at the focus of research in this paper (Figure 1), this being the easternmost wine-growing

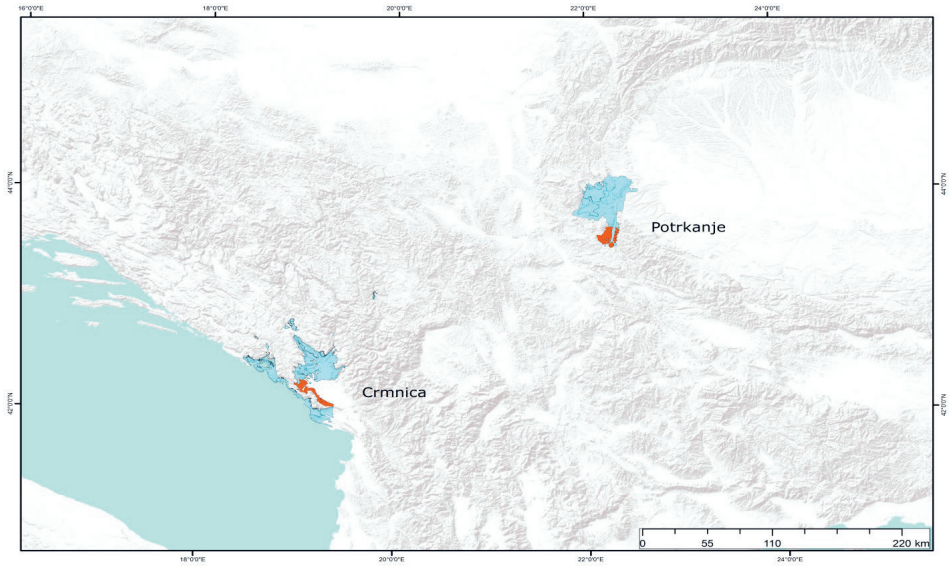

Figure 1. Wine-growing areas of Montenegro and Knjaževac wine-growing region

region in Serbia, i. e. the easternmost point of cultivation of the Vranac variety cultivation area.

The research was particularly focused on the Potrkanje wine-growing locality which consists of three sections (micro localities) in the Potrkanje village area (Figure 2). Wines whose quality parameters were examined were produced from grapes produced in this locality.

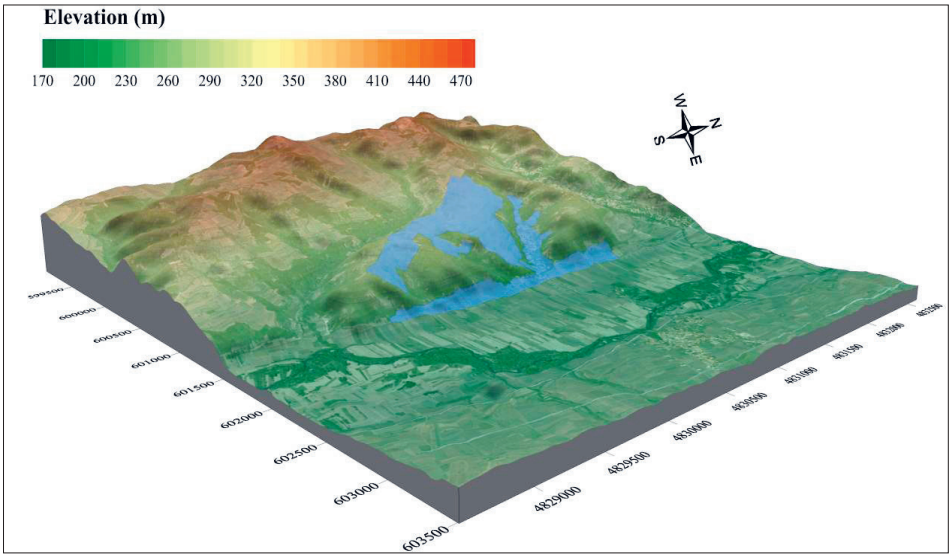

Figure 2. Potrkanje locality

METHODOLOGY

Study of 436 vineyards (among which were those with the Vranac variety) of the Knjaževac wine-growing region was conducted using GIS (geographical information system) technology, i. e. digital data sources, which enabled determination of quantity parameters of the relief of examined vineyards. Topographical information was used for spatial analysis and modelling, that is for obtaining spatial information on the slope, exposure and altitude of vineyards. Information was derived from the digital elevation model (DEM) with 30m precision, while the Aster GDEM v2 was the basic input in analysis of wine-growing areas and vineyards. The following GIS software packages were used in this paper: Global Mapper 13 and Qgis v2.18, as well as Google Earth, the geo statistics data processing was conducted using the ArcGIS software program, i. e. its extensions Spatial Analyst and Geostatistical Analyst.

Wine-growing information on varieties, rootstocks, vineyard ages, training systems and other wine-growing information (only some of which are presented in this paper) for the 436 vineyards were obtained through field research within the Vineyard register system, which was carried out by the Center for Viticulture and Oenology partially for the benefit of the Ministry of Agriculture, Forestry and Water Management.

Measurement of vineyard surfaces and determination of their spatial position was carried out through application of contemporary GPS devices of the TOPCON GRS-1 brand, 1 cm precision, with guaranteed precision of 30 cm and with support from mobile operator stations, and with orthography with 20–40 cm precision and NIGP and official digitalized cadastral maps of the Serbian State Geodetic Bureau.

Climate data used in this paper was obtained through analysis of data for the 42-year period with interpolation of data in years when analyses were not carried out (1961–2010), these information were determined by Vuković, Vujadinović-Mandić and others during the zoning of Serbian wine-growing areas which were, based on this, defined in the By-Law on Zoning of Wine-Growing Geographical Production Areas in Serbia ("Official Gazette of RS", no. 45/15). For the purposes of this paper, values were analyzed from the meteorological station in Knjaževac (Latitude: 43°56'67"; Longitude: 22°25'00"; Altitude: 250 m) in the proximity of which the majority of vineyards with the Vranac variety are located.

Analysis of wines from the 2011, 2013 and 2015 vintages of the Vranac variety from the Potrkanje locality was conducted in the laboratory of the Centro di Ricerca e Sperimentazione Formazione e Agricoltura "Basile Caramia" Locorotondo (Bari, Italy). Analysis of 25 wine quality parameters was carried out by application of WineScan Flex (FTIR Technology).

RESULTS AND DISCUSSION

Climate conditions in the Knjaževac wine-growing region are typical for continental conditions, with the average annual temperature in Knjaževac being 11.0 °C. Mean monthly temperatures are the highest in July and August while September, as an important month for ripening of the Vranac variety grapes, has a favorable mean temperature (Figure 3).

With respect to precipitation, the average annual precipitation in Knjaževac is 592.3 mm, and the average total precipitation in September is more than 50 mm and in October less than 50 mm (Figure 4), which results in high quality and healthy grapes of the Vranac variety and an unimpeded grape harvest.

Analyzed bioclimatic indices as prescribed by the OIV indicate that there are favorable climate conditions for wine growing in the Knjaževac wine-growing region (Table 1). The aforementioned bioclimatic indices are significantly different from the same indices in the Crmnica wine-growing subregion (from which the Vranac variety originates) which is situated in the warmer IV (CII) climate zone in accordance with WI (Winkler degree days). In addition, the leading type of soil in Knjaževac wine-growing region is vertisol, while in Crmnica wine-growing subregion is the *terra rossa* and brown

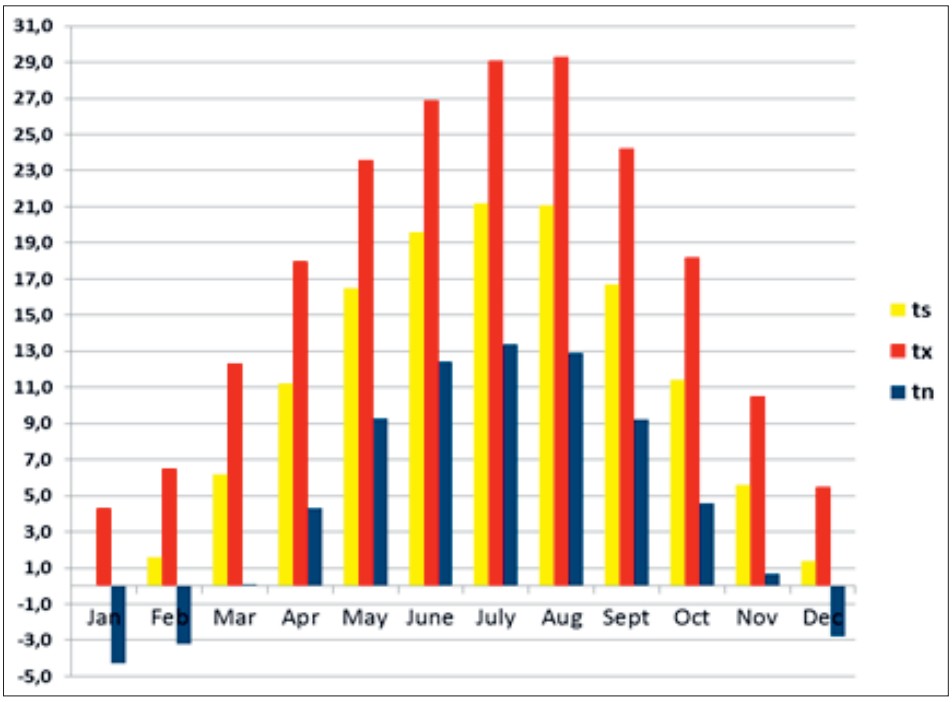

Figure 3. Average (ts)/maximum (tx)/minimum (tn) monthly temperature (°C)

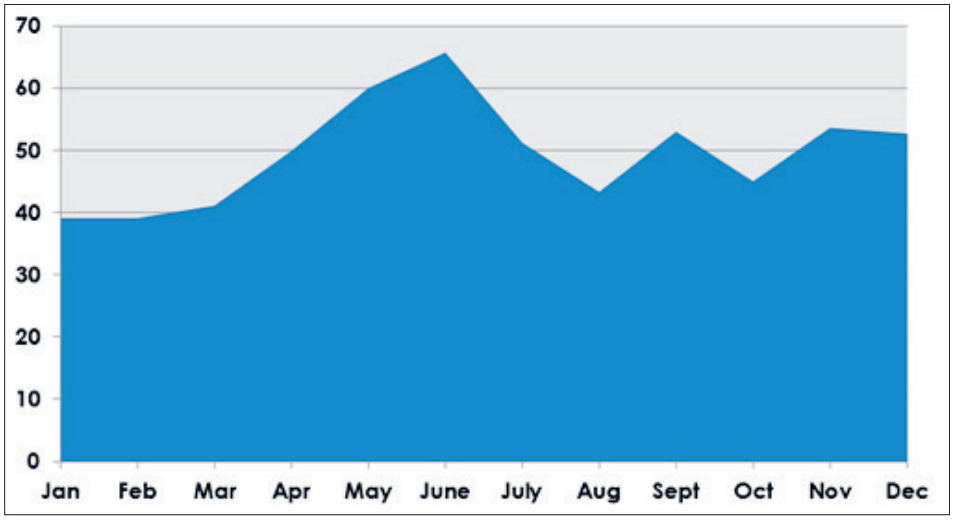

Figure 4. Average monthly rainfall sum (mm)

soil. This may indicate that the Vranac variety is an adaptable one and that it can produce grapes and wines of excellent quality in wine-growing areas with differing agroecological conditions.

One of the main characteristics of the Knjaževac region with respect to OIV bioclimatic indices is the Cool Night Index (CI), which confirms the high potential of this region for production of secondary metabolites (colored and aromatic maters) in grapes.

Examination of 436 vineyards (vineyard parcels) in the Knjaževac wine-growing region resulted in findings that the Vranac variety is eighth with

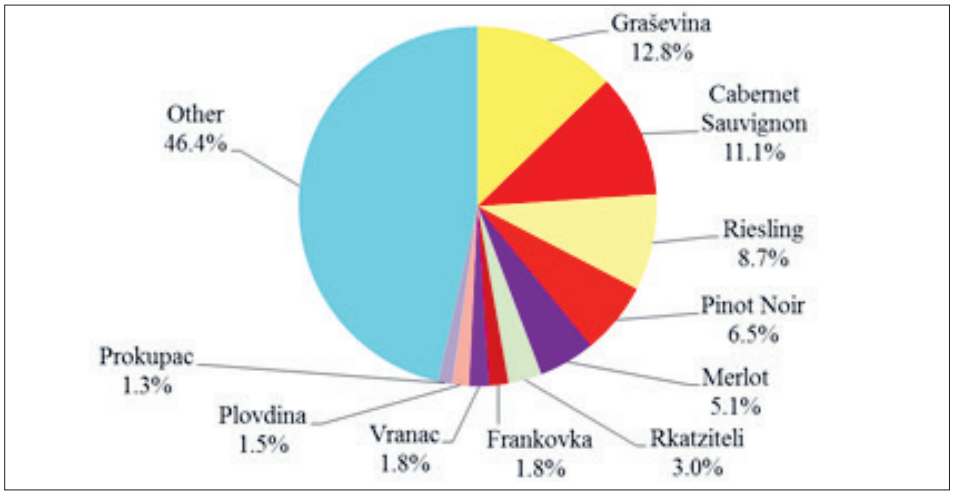

Figure 5. Structure of vineyards by varieties in Knjaževac wine-growing region

Table 1. Overview of the OIV bioclimatic indices in the Knjaževac wine-growing region

OIV BIOCLIMATIC INDICES	KNJAŽEVAC
RISK INDICATORS BASED ON EXTREME TEMPERATURES	
Minimum freezing temperature during the growing period (No. of days with 0 °C) *(Fuller and Telli, 1999)*	2.2
Maximum temperature during the growing and grape ripening period (No. of days with 35 °C) *(Hüglin and Schneider, 1998), (Spayd et al. 2002; Kliewer, 1977)*	7.0
INDICES BASED ON THE GROWING SEASON AIR TEMPERATURE, INDICATORS OF VINE DEVELOPMENT AND GRAPE RIPENING KINETIC	
Average growing season temperature — AVG (jan-oct) (°C) *(Jones et al., 2005)*	16.8
Winkler degree days — WI (°C day) *(Amerine and Winkler, 1944)*	1,524.8 (II/ B)
Biologically Effective Degree Days — BEDD (°C day) *(Gladstones, 1992)*	1,293.6
Huglin Heliothermal Index — HI (apr-sep) (°C day) *(Huglin, 1978)*	2,167.1 (HI + 1 — climate class: Warm)
INDICES BASED ON NIGHT TEMPERATURES AND/OR THE TEMPERATURE RANGE, INDICATORS OF GRAPE RIPENING CONDITIONS	
Cool Night Index — CI (sep) (°C)	9.7 CI + 2 (climate class: cold nights)
VITIVINICULTURE CLIMATIC WATER BALANCE, INDICATOR OF THE WATER OFFER AT CLIMATE LEVEL	
Drought index — DI (apr — sep) (mm)	151.8 (DI-2 / Climate class: Humid)

respect to surfaces in all vineyards (Figure 5), which is similar to the share of this variety in vineyards in Serbia in total (1.74%). A smaller share of this variety with respect to surfaces is understandable considering that, due to climate and soil conditions in the Knjaževac wine-growing region, surfaces planted with white wine varieties dominate (40.7%), even though the Vranac variety is especially highly regarded in this wine-growing region.

Through application of GIS technology, it was determined that the majority of the examined 436 vineyards are situated in altitudes ranging from 200 to 300 m (Figure 6). With respect to surfaces, the majority of vineyard surfaces are situated in altitudes in the 300 to 400 m range (Figure 7). This, relatively high, altitudes in which vineyards are situated certainly have an impact on the quality and characteristics of all wines from the Knjaževac region, including the Vranac variety wines.

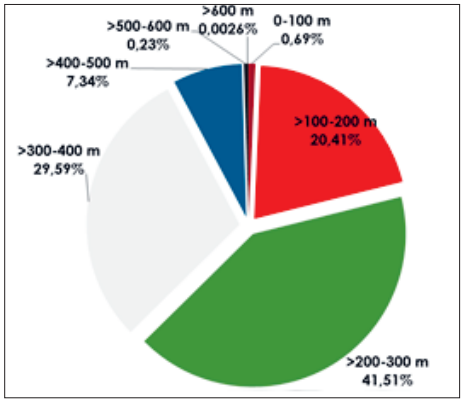

Figure 6. Structure of altitude of vineyards

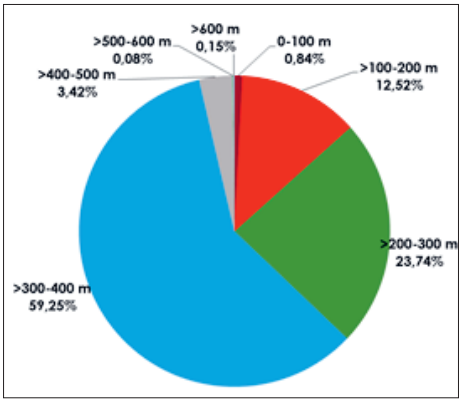

Figure 7. Structure of surfaces of altitude of vineyards

Regarding terrain exposure, most of the vineyards have eastern, southern and south-eastern exposure (Figure 8); however, looking at the surfaces of examined vineyards the dominant exposure is north-eastern, followed by eastern exposure (Figure 9).

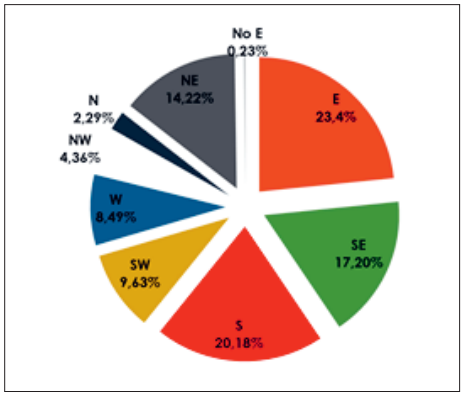

Figure 8. Structure of exposition of vineyards

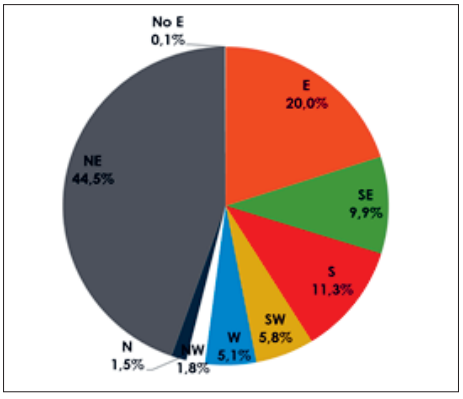

Figure 9. Structure of surfaces of exposition of vineyards

Slope of the terrain on which the examined vineyards are planted is predominantly 5° to 10°, both with respect to the number of vineyards (Figure 10) and with respect to surfaces of examined vineyards (Figure 11).

Within the Potrkanje locality, in which the Vranac variety vineyards are located and which is at the same time the easternmost point of cultivation of this variety in the Balkan Peninsula, this research focused on three vineyard micro-locations whose orthographic conditions were examined in detail:

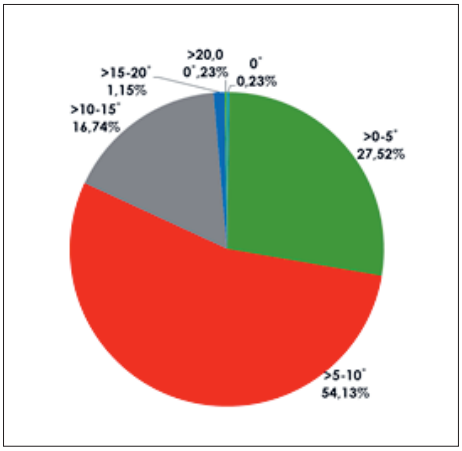

Figure 10. Structure of slope of vineyards

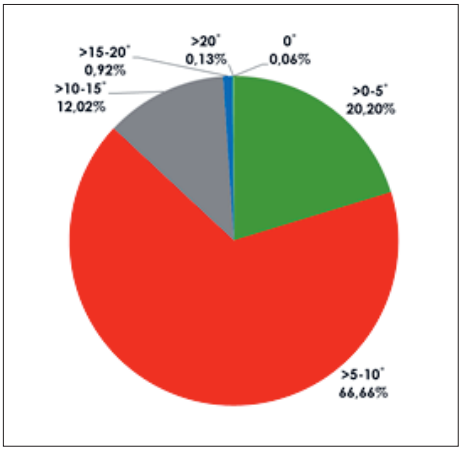

Figure 11. Structure of surfaces of slope of vineyards

— Location 1 (Lower zone),
— Location 2 (Upper zone),
— Location 3 (Village).

Regarding exposure, in Location 1 in which newly planted vineyards are located, the eastern terrain exposure is dominant (57.30%) (Figure 12).

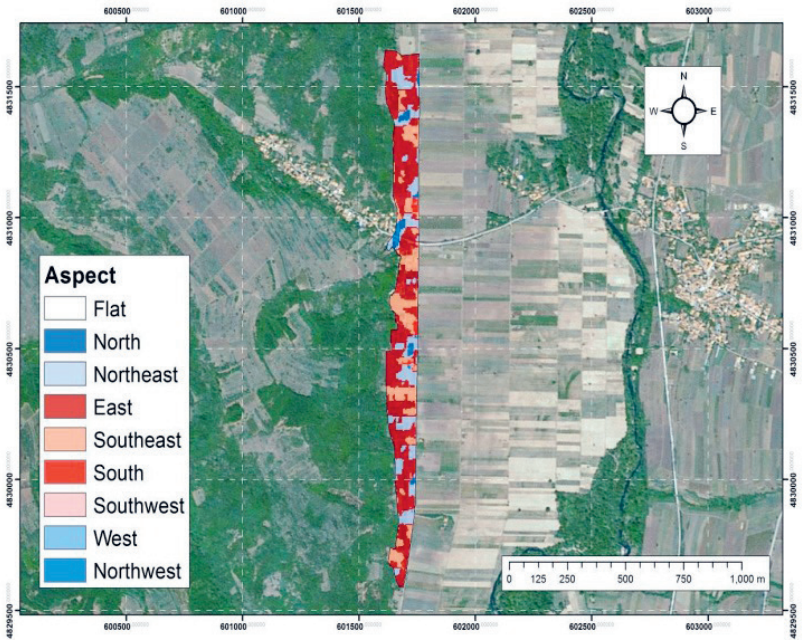

Figure 12. Aspect of Location 1

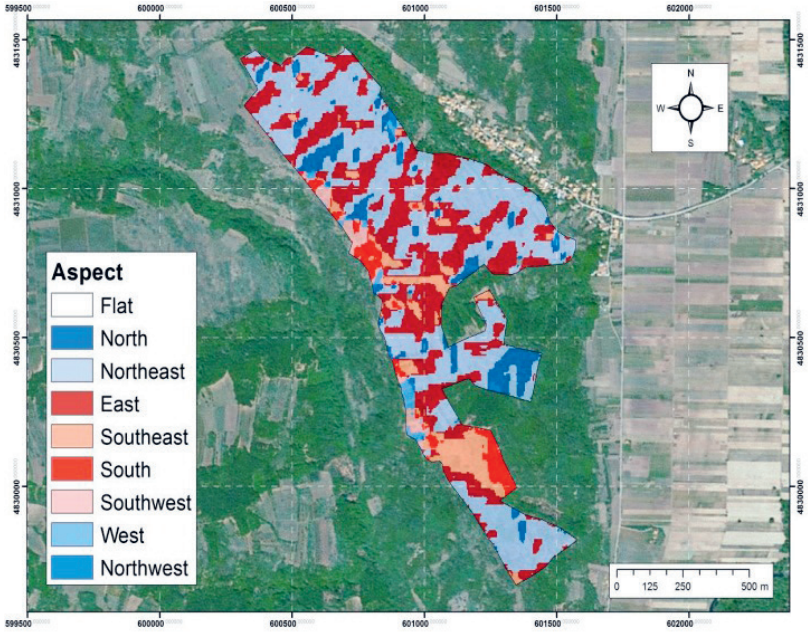

Figure 13. Aspect of Location 2

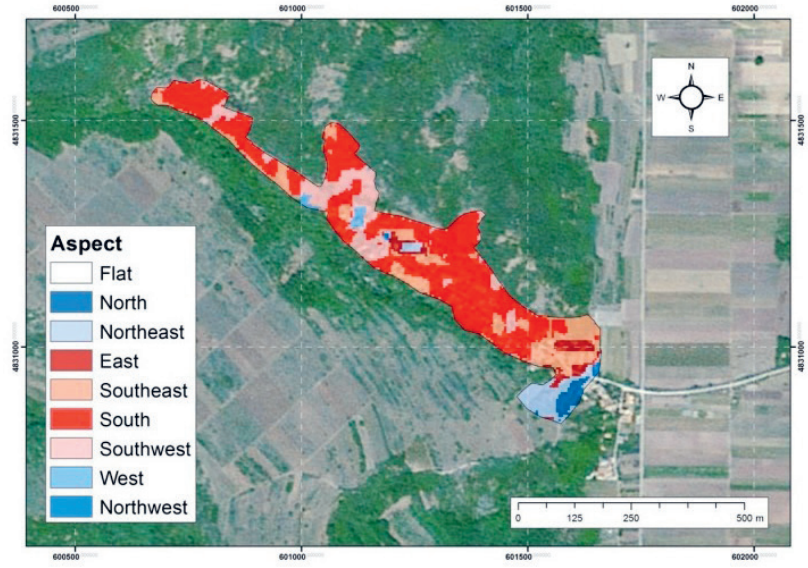

Figure 14. Aspect of Location 3

Location 2, which has the highest concentration of Vranac variety vineyards, is somewhat different with north-eastern (46.72%) and eastern (30.10% of the totality of all exposure) exposure dominating (Figure 13).

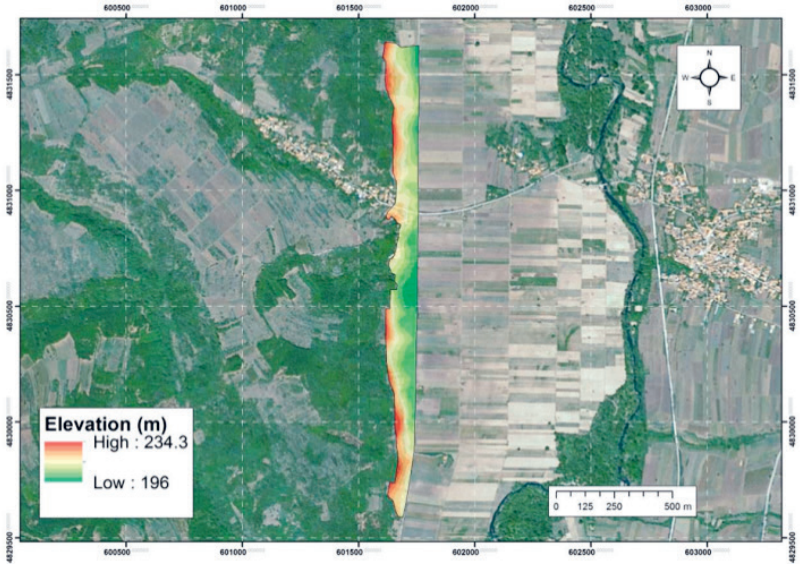

Figure 15. Elevation of Location 1

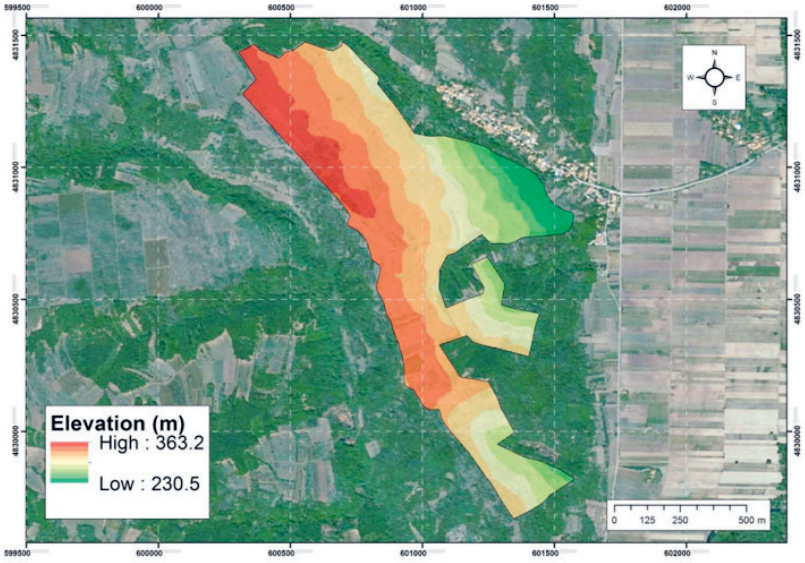

Figure 16. Elevation of Location 2

In Location 3, in which small vineyards planted with mixed vine varieties are located, southern exposure is dominant with 54.00% in all surfaces (Figure 14).

All three locations are situated on the elevation ranging between 196 and 363.2 m, with Location 1 being on the lowest elevation and Location 2 on

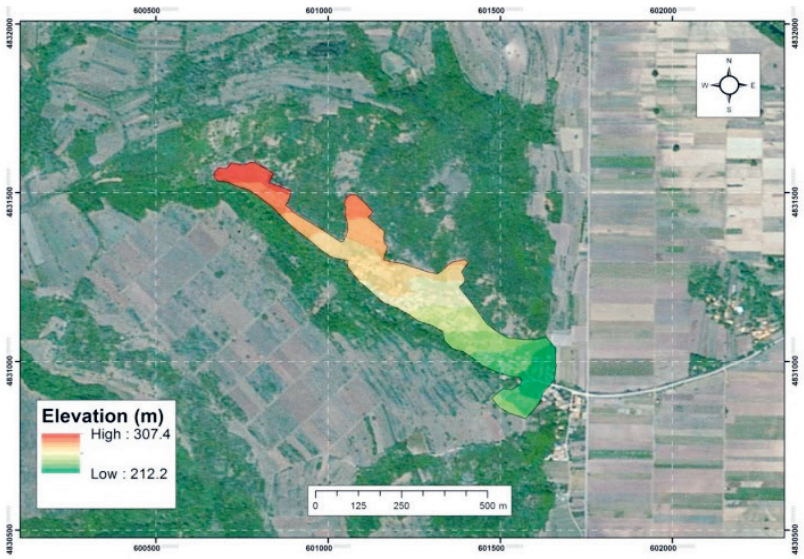

Figure 17. Elevation of Location 3

the highest (Figures 15, 16 and 17), the average elevation of vineyards with the Vranac variety is 306 m.

Terrain slope is relatively pronounced in all three locations, the majority of terrain in Location 1 and Location 2 has the slope in excess of 20% (Figure 18 and Figure 19). The majority of terrain in Location 3 has the slope ranging between 10 and 15% (Figure 20).

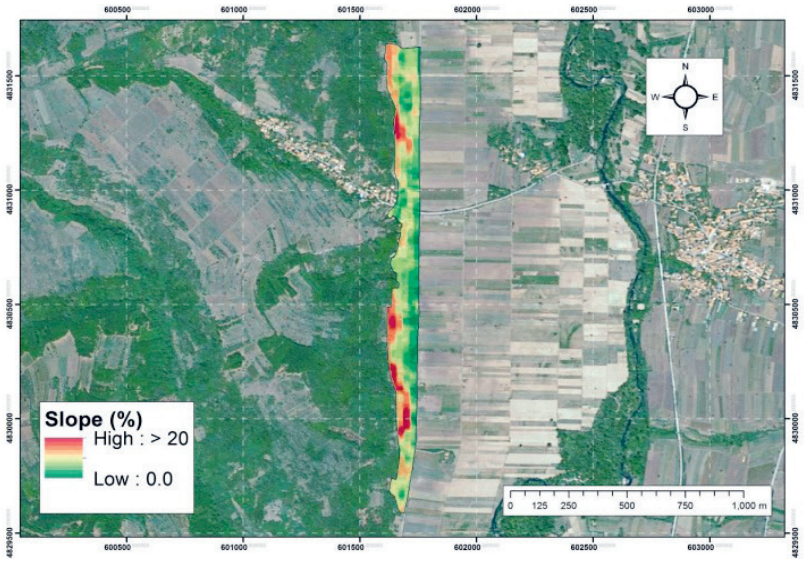

Figure 18. Slope of Location 1

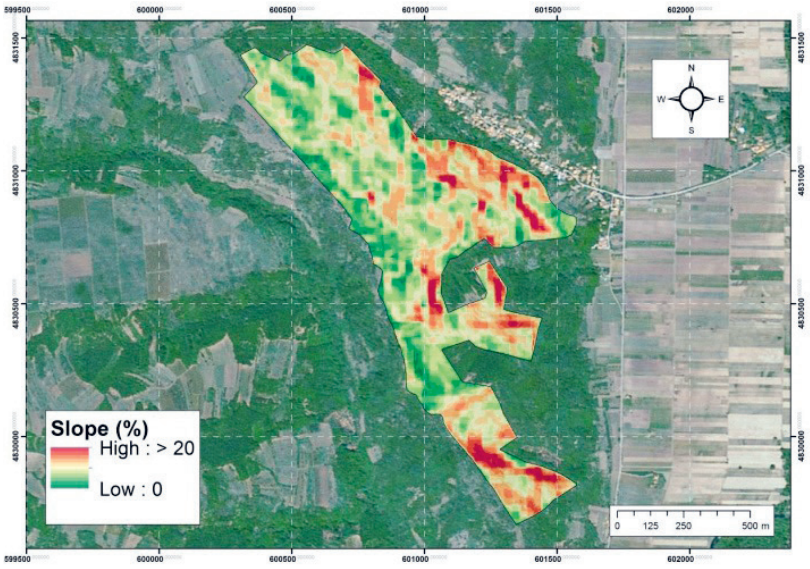

Figure 19. Slope of Location 2

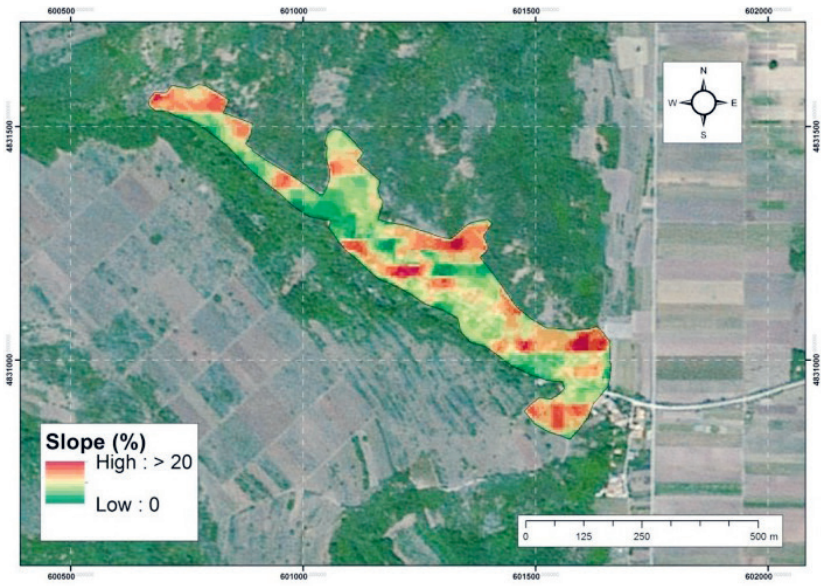

Figure 20. Slope of Location 3

With respect to the Winkler index, a characteristic of all three micro-locations in the Potrkanje locality is that they belong to the relatively cold II WI climate zone (B climate zone in the European Union classification) which ranges in the interval between 1.372 to 1.649 °C (Figure 21, 22 and 23).

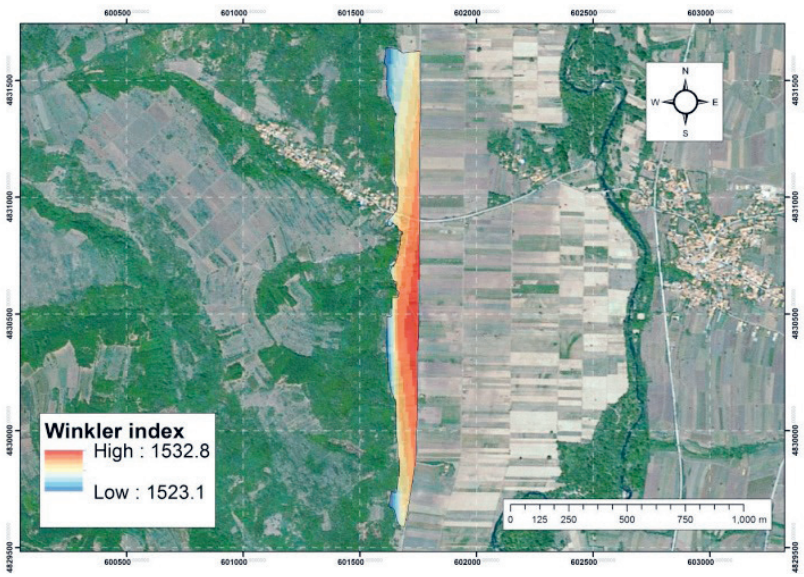

Figure 21. WI of Location 1

This data indicates that the Vranac variety can be successfully cultivated in certain localities which belong to the II WI climate zone as well, keeping in mind that these localities should not be in depressions and exposed to frost.

As part of the research for this paper, Vranac variety wines which received the best marks in the process of certification of geographic indication

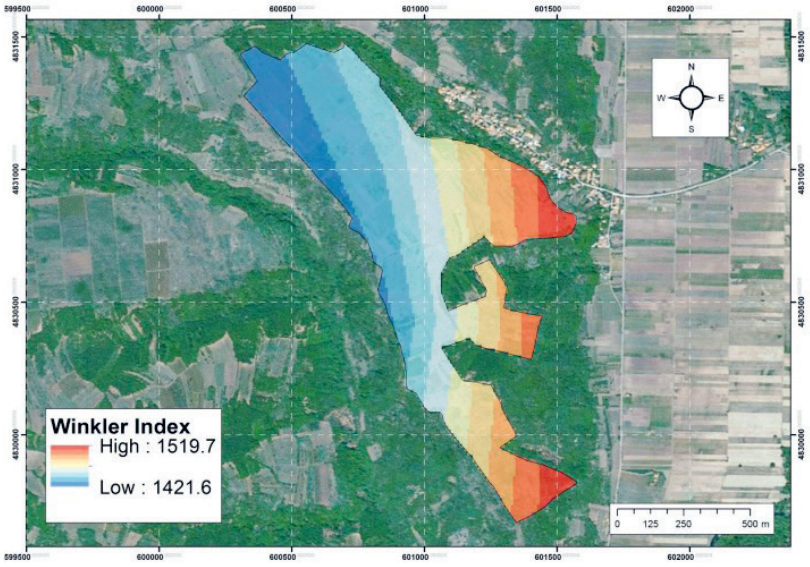

Figure 22. WI of Location 2

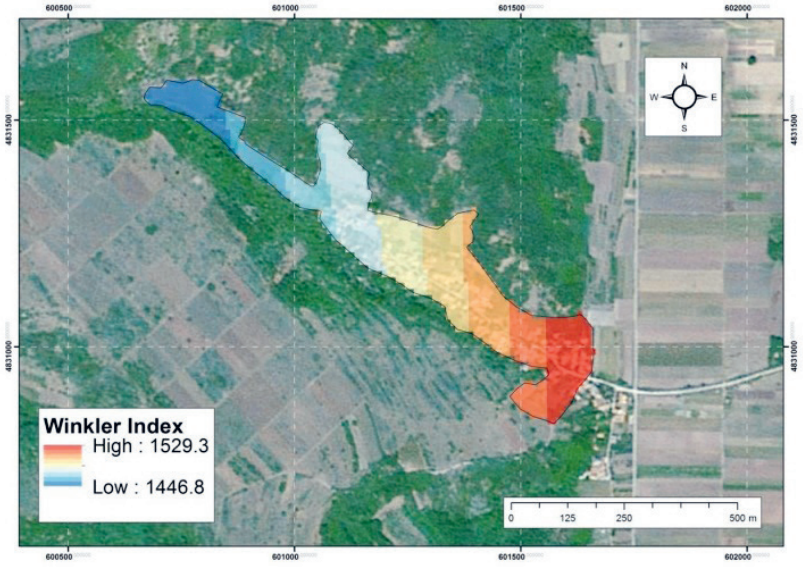

Figure 23. WI of Location 3

and obtained the traditional label of "highest quality K. G. P. K. wine" and the purple stamp as confirmation of the highest category of wines were analyzed (Table 2). These wines, from the 2011, 2013 and 2015 vintage, produced from Vranac variety grapes from the Potrkanje locality and in the process of certification, were graded in sensory evaluation with at least 89 point out of the maximum of 100.

Wines of all analyzed vintages were dry, with a high content of actual alcohol and optimal pH. With respect to total acid content, wines from 2011 and 2013 have a higher content, while wines from 2015 have a medium-high total acid content. Density of examined wines was medium-high (for wines from 2011 and 2015) and high (wines from 2013). All wines were highly extractive, i. e. wines from 2011 and 2013 vintages have high extract content and wines from 2015 have higher extract content. With respect to total polyphenols, analyzed wines have a lower content, but a predominantly middle to moderately-high content of anthocyanin, with red (A520) pigments being dominant with respect to color intensity.

Information on the aforementioned analyzed parameters indicate a high quality and good characteristics of wines from the Vranac variety from the Potrkanje locality, as well as the possibility of cultivation of this variety with excellent results in certain localities even in colder wine-growing areas such as the Knjaževac wine-growing region.

Table 2. Quality parameters of wine of Vranac variety from the Potrkanje locality

WINE QUALITY PARAMETERS	2011	2013	2015
Content of Actual Alcohol *(%Vol)*	14.46	14.36	14.22
Sweetness/content of residual sugar *(g/l)*	1.51	3.83	0.85
pH	3.25	3.25	3.35
Volatile acids *(g/l)*	0.46	0.60	0.45
The total acid content *(g/l)*	6.65	6.97	5.58
Density (specific gravity at 20 °C) *(g/ml)*	0.99285	0.99432	0.99259
Extract *(g/ml)*	30.07	33.44	28.49
Malic Acids	1.59	1.47	0.88
Lactic Acids	0.74	0.43	0.39
Tartaric Acids	2.56	2.32	3.34
Citric Acids	0.16	0.22	0.17
Glycerol *(g/l)*	10.09	11.44	9.26
Methanol *(%)*	0.15	0.18	0.16
Potassium *(g/l)*	1.02	0.82	0.72
Ash *(g/l)*	2.62	2.13	2.13
Sulphate content *(g/l)*	0.60	0.55	0.48
CO_2 *(mg/l)*	817	508	560
Total SO_2 *(mg/l)*	106	120	67
Total polyphenols *(mg/l)*	2.148	1.832	1.864
Total anthocyanins *(mg/l)*	358	306	479
Intensity of color — A420	0.515	0.362	0.525
Intensity of color — A520	0.766	0.508	0.919
Intensity of color — A620	0.149	0.091	0.144
Overall color intensity	1.43	0.96	1.59
Tone	0.67	0.71	0.57

CONCLUSION

Vranac is a variety which originates from Montenegro and has, due to the quality of its grapes and its adaptability, spread to other wine-growing areas of the Balkan Peninsula. This variety is highly appreciated in Serbia and based on research of commercial vineyards it was determined that the easternmost point of cultivation of this variety is the Potrkanje locality situated in the Knjaževac wine-growing region in the very east of the country. Following examination of three micro-locations in this locality with use of GIS technology, laboratory examination determined that wines from the Vranac variety in this locality have a high quality, although this wine-growing region belongs to the colder II (B) climate WI zone and vineyards are situated in a relatively higher altitude. Given the positive results obtained in this research, it can be concluded that there is a possibility of further spreading

of the area in which the Vranac variety is cultivated. Rising of vineyards in other wine-growing areas in continental climate requires detailed examination of favorable conditions in other individual representative localities in these wine-growing areas.

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Darko JAKŠIĆ, Pierfederico LA NOTTE, Pamela Beatrice GIANNINI,
Veljko PEROVIĆ, Alessandra CAGNAZZO

CRNOGORSKA VINSKA SORTA VRANAC U NAJISTOČNIJEM DIJELU PODRUČJA GAJENJA — KNJAŽEVAČKI REGION

Sažetak

Za crnogorsku sortu vranac postoji mišljenje da se visokokvalitetna vina ove sorte mogu proizvoditi uglavnom u mediteranskom podneblju i da nema mogućnosti širenja ove sorte izvan toplijih područja. Najistočnija tačka na kojoj se gaji vranac je Knjaževački vinogradarski region (Srbija), lokalitet Potrkanje, kojeg karakteriše hladnija klima (B klima Winkler zona) i vinogradi na prosječnoj nadmorskoj visini od 306 m. U takvim uslovima sredine, vina proizvedena od ove sorte se redovno ocjenjuju kao vina najboljeg kvaliteta „vrhunsko K. G. P. K. vino" sa pečatima kvaliteta i porijekla u okviru „PDO/PGI" sistema geografskog porijekla Srbije.

U ovom radu je izložena detaljna analiza vina, koja je sprovedena u Italiji, primjenom visoko sofisticirane laboratorijske opreme gdje je izvršena analiza vina od sorte vranac iz Knjaževačkog vinogradarskog regiona (Potrkanje lokalitet) iz berbe 2011, 2013 i 2015. Laboratorijska analiza parametara kvaliteta, uključujući ukupne antocijane, intenzitet boje, nijansu boje vina (A420, A520, A620) itd. za karakterizaciju kvaliteta i specifičnost vina od sorte vranac iz Knjaževačkog vinogradarskog regiona, je urađena. U ovom radu, izvjesne pozitivne osobine kvaliteta vina od sorte vranac su utvrđene, bez obzira na činjenicu da su vinogradi u potpuno različitim klimatskim i zemljišnim uslovima u odnosu na prvobitne uslove u Crnoj Gori.

Ključne riječi: sorta vranac, parametri kvaliteta vina, Knjaževački vinogradarski region