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# YIELD AND OENOLOGICAL POTENTIAL OF MONTENEGRIN AUTOCHTHONOUS GRAPE VARIETIES 'KRATOŠIJA' AND 'ŽIŽAK'

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## Abstract

The influence of five different grape yields on the quality of grapes and wines of autochthonous red grapevine variety 'Kratošija' ('Zinfandel') and white grapevine variety 'Žižak', in sub-region Podgorica was investigated.

The aim of this study was to determine which yield has the best effects on grape and wine quality of grapevine varieties investigated. As result of multiyear investigation (2009 - 2012) and research of yield parameters, in order to achieve the optimal quality of grape and wine, we decided to leave different number of buds within both varieties. By different kind of winter pruning within 'Kratošija' variety it is approximately achieved yield of 6, 8, 11, 13 and 15 t/ha, while within 'Žižak' variety 6, 8, 9, 10 and 12 t/ha was achieved. During vegetation yield parameters (average number of bunch per vine, average weight of bunch, average yield per vine) and quality parameters (sugar content, pH and total acids) of grape were monitored. Average yield was determined by measuring harvested grape weight of fifteen marked vines, while average weight of bunch was determined by dividing of total grape weight by total number of bunches. Sugar content was determined using Oechesle's hydrometer, total acids and pH by potentiometric method. Wine quality parameters: alcohol content, total dry extract were determined by densitometry, reducing sugar, total and free $SO_2$ by titration method and total polyphenols and anthocyanins by spectrophotometric methods. Sensory analysis was done by OIV 100 points evaluation method.

Based on obtained results of 'Kratošija' variety, it was concluded that the best quality of grapes and wines achieved at yield of 8 t/ha (sugar content (23.9%), alcohol (13.49 vol%) and total dry extract (31.5 g/l)), what is also confirmed by sensory analysis (84.00). The optimal chemical (sugar content (22.8%), alcohol (14.20 vol%) and total dry extract (23.5 g/L) and sensorial parameters (86.25) of 'Žižak' variety was achieved at yield of 12 t/ha.

***Key words**: Autochthonous grape varieties, Yield, Grape quality, Wine quality, Sensor analysis.*

## 1. Introduction

Primary requirement for production of high-quality wine is grape quality. Wine composition depends on variety, climatic conditions, soil, and cultivation techniques used [1], [2], [3], [4], [5]. Viticulture has a long tradition in Montenegro and autochthonous grapevine varieties ('Vranac', 'Kratošija', 'Krstač' and 'Žižak') have very important role in viticulture and winemaking sector. They are the most represented in vineyards and recognizable high quality wines are made from them. In this paper the impact of different yield and oenological potential of red grapevine variety 'Kratošija' ('Zinfandel') and white grapevine variety 'Žižak' is represented. According to many literature data [6], [7], [8] 'Kratošija' is Montenegrin autochthonous grapevine variety, grown in Montenegro for centuries. 'Kratošija' is heterogeneous variety in term of expressing its attributes, which led to the appearance of series varieties-biotype with obvious differences, which caused its lower representation in Montenegrin vineyards [9]. It is confirmed by genetic analysis that 'Kratošija' has identical genetic profile as 'Zinfandel' from California, 'Primitivo' from Italy and 'Crljenak kaštelanski' from Croatia [10]. Kratošija wine is characterized by an intense ruby-red color and aroma of red berry fruits and an extremely pleasant taste; it has a light and harmonious structure and smooth finish. 'Žižak' variety is autochthonous Montenegrin variety; its vines can be fined in the vicinity of Podgorica, Crmnica and Montenegrin coast [11]. Žižak wine has green-yellow color, good body, fullness and aroma of southern fruit.

Crop control is a priority in many viticultural areas of the world to assure high quality wines, and it can be traditionally achieved with winter pruning. To propose proper number of buds per vine for a certain grape variety, in a defined soil type, climatic conditions, is very difficult. Since there are few available data of the effects of the grape yield on quality parameters of wine, the need for study the correlations between crop yields and some quality parameters of wine has shown up. Some studies have reported reduced grape maturity and impaired grape colour in grapes from vineyard with a high yield [12]. Tomić *et al*. [13] did one year research on 'Kratošija' variety and concluded that the yield of 12 t/ha achieved satisfying quality of grape and wine, while 8 t/ha distinguished with wine quality. Košmerl *et al*. [14] did similar investigation on four Montenegrin autochthonous grape varieties ('Vranac', 'Kratošija', 'Krstač' and 'Žižak') and determined the correlation between grape yield and wine quality parameters such as content of total polyphenols, anthocyanins, reducing sugars and antioxidant potential. As results of this research, a poor correlation among yield and quality parameters has been found, what mean that reduction in crop load did not improve the quality parameters. It is clear that the relationship between yield and quality is not straightforward one and wine grape growers should investigate their own optimum yields that will produce quality wine grapes [15]. Also the wines from low-yield vineyards were considered, by the tasters, to have better sensory quality than the wines from high-yield vineyards [16]. It was also noticed by Pozo-Bayon *et al*. [16], that the concentrations of most phenolic compounds were higher in wines from vineyards with a high yield than in those with a low yield.

Most studies on the relationship between vineyard yield and wine quality have been carried out using Oechesle's, pH and total acids as parameters of quality since these are usually aimed at studying grapes for use in the manufacture of wines [16]. Therefore, it is also necessary to know the influence of vineyard yield on other parameters directly related to the quality of wines [17]. Vine yield have been evaluated with respect to grape composition at harvest, their effects on final wine quality and sensory properties. With this aim, wines were made proceeding from grapes of 'Kratošija' and 'Žižak' variety with different yield, which is achieved by winter pruning. Yield parameters: average number of bunch per vine, average weight of bunch and average yield per vine were monitored. In order to harvest grape in its oenological maturity, sugar content, total acids and pH were determined periodically. Regarding to wine quality, alcohol content, total dry extract, reducing sugars, polyphenols, anthocyanins and the sensory analysis were determined. Based on obtained results of 'Kratošija' variety, it was concluded that the best quality of grapes and wines achieved at yield of 8 t/ha, what is also confirmed by sensory analysis. The optimal chemical and sensorial parameters of 'Žižak' variety was achieved at yield of 12 t/ha.

## 2. Materials and Methods

The study was carried out in 2013 season in experimental vineyard on Ćemovsko field, grape variety 'Kratošija' was planted in 2003 and 'Žižak' was planted in 2000 year. The distance of planting in the 'Kratošija' vineyard was 2.6 m ´ 0.7 m (5495 vines/ha), Paulsen 1103P rootstock was used and vines were formed in the shape of single Guyot. The distance of planting in the 'Žižak' vineyard was, 2.6 m ´ 1.2 m (3205 vines/ha), Kober 5BB rootstock was used and vines were formed in the shape of double horizontal cordon. Short and mixed pruning was used depending of the planned yield. All standard agro-technical operations were applied and vineyards were in good and healthy condition.

Within both examined varieties different buds load per vine was left by winter pruning, in order to achieve different grape yield. All necessary indicators of real and potential fertility for each examined yield were followed. For every combination of yield, three repetitions of 5 vines (15 vines) were included in research for following these indicators. One of the most important characteristics - potential fertility was determined during flowering phase. Fertility coefficients were calculated based on data (potential buds fertility coefficient, shoot fertility coefficient and absolute shoot coefficient). Also during vegetation yield parameters (average number of bunch per vine, average weight of bunch, average yield per vine) and grape quality parameters (sugar content, pH and total acids) were monitored. Average yield was determined by measuring harvested grape weight of fifteen marked vines; while average weight of bunch was determined by dividing of total grape weight by total number of bunches. Within 'Kratošija' approximately yields of 6, 8, 11, 13 and 15 t/ha were reached, while yields of 6, 8, 9, 10 and 12 t/ha were reached within 'Žižak' variety. Agro-biological, economics and technological characteristics of all different achieved yields within both varieties were followed.

Wines were produced on a microvinification scale. At harvest, grapes from all different yields were harvested manually and transported to the experimental cellar. For the vinification we used an average grape sample of each yield as follows: 164 kg of 'Žižak' and 300 kg of 'Kratošija' variety. Potassium metabisulfite, purchased from Agroterm KFT, Hungary was added; 8 g 100 kg$^{-1}$ of 'Žižak' grapes and 10 g 100 kg$^{-1}$ of 'Kratošija' grapes. All enzymes, wine yeast, lactic acid bacteria and yeast nutrients were obtained from Lallemand, Australia. Lallzyme Cuvee Blanc for maceration (2 g 100 kg$^{-1}$), Lallzyme HC for clarification (1 g hL$^{-1}$), yeast Lalvin ICV-D47 (30 g hL$^{-1}$), Go-ferm protect (30 g hL$^{-1}$) and Opti white (30 g hL$^{-1}$) were added during vinification of 'Žižak' variety. Enzyme Lalvin EX-V for maceration (2 g 100 kg$^{-1}$), yeast Lalvin BM 4x4 (30 g hL$^{-1}$) and Go-ferm protect (30 g hL$^{-1}$) were added during vinification of

'Kratošija' variety. Yeast nutrient, Fermaid E (25 g $hL^{-1}$) was added during fermentation of both varieties. After alcoholic fermentation wines were racked and malolactic fermentation occurred. In Kratošija wine lactic acid bacteria Lalvin VP41 (1 g $hL^{-1}$) was inoculated, while in Žižak wine the malolactic fermentation was spontaneous. After completion of malolactic fermentation Kratošija wine was racked and potassium metabisulfite was added in amount depending of free $SO_2$ in analysed wine samples. Malolactic fermentation in Žižak wine was stopped on half and potassium metabisulfite was also added in amount depending of free $SO_2$ in analysed wine samples. After this operation, wines of both varieties of each yield underwent cold stabilisation during two weeks. After two months aging in glass vessels, Žižak wine was bottled, while Kratošija wine was bottled after 6 months of aging in glass vessels.

For determination of basic wine chemical parameters, reducing sugars, alcohol, total acidity, tartaric acid, pH value, total dry extract, total and free $SO_2$ the reference methods of European Union [18] were used. Total polyphenols and anthocyanins content were determined by spectrophotometer. Total polyphenols were quantified by Folin-Ciocalteu index method [19]. The total anthocyanins were determined using the pH differential method [20]. Determination of reducing sugars content was done using the Luff-Schoorl method.

## 3. Results and Discussion

### *3.1 Grape yield*

As result of multiyear investigation (2009 - 2012) and research of yield parameters, in order to achieve the optimal quality of grape and wine, we decided to leave different number of buds within both varieties. In dependence of buds number per vine, short and mixed winter pruning was applied. By winter pruning within 'Kratošija' variety it is approximately achieved yield of 6, 8, 11, 13 and 15 t/ha, while within 'Žižak' variety 6, 8, 9, 10 and 12 t/ha was achieved. Table 1 shows achieved yield parameters (average number of bunch per vine, average weight of bunch, average yield per vine) in dependence of left buds number per vine by winter pruning within both varieties.

According to the Avramov [21] 'Kratošija' is grape variety with high yield (12 - 15 t/ha even more), average bunch weight varies from 200 to 270 g. High yields can be achieved by winter pruning with long spurs, or better with mixed pruning (short canes) [22]. By analysing achieved data (Table 1) it is noticed that within 'Kratošija' variety, the lowest number of bunch was at 5 and 6 buds per vine left, what is also confirmed with the lowest yield per vine and achieved yield per ha. Pruning with 6 buds per vine gave the lowest average bunch weight (169.45 g), as well as, the lowest yield per vine (1.10 kg) and yield per ha (6.01 t/ha). The highest yield per vine (2.76 kg) and per ha (15.14 t) is achieved when 8 buds per vine were left, and that gave the highest average bunch weight (240.43 g). Also buds load increase leads to decrease of buds and shoot fertility, the percentage of un-awakened buds and percentage of unfertile shoots [23].

**Table 1. Yield parameters in dependence of left bud number per vine (2013)**

| Grape variety | Number of buds per vine | Average number of bunch per vine | Average bunch weight (g) | Yield per vine (kg/vine) | Average yield per ha (t/ha) |
|---|---|---|---|---|---|
| 'Kratošija' | 5 | 6.46 | 220.74 | 1.43 | 7.84 |
| | 6 | 6.46 | 169.45 | 1.10 | 6.01 |
| | 8 | 11.46 | 240.43 | 2.76 | 15.14 |
| | 10 | 11.13 | 215.90 | 2.40 | 13.20 |
| | 12 | 8.86 | 219.90 | 1.95 | 10.70 |
| 'Žižak' | 7 | 10.46 | 193.24 | 2.02 | 6.48 |
| | 10 | 14.33 | 174.81 | 2.51 | 8.03 |
| | 12 | 17.26 | 209.91 | 3.62 | 11.61 |
| | 14 | 18.2 | 167.69 | 3.05 | 9.78 |
| | 18 | 17.8 | 160.52 | 2.86 | 9.16 |

'Žižak' variety is not so examined as 'Kratošija' is, and there are less data about its agro-biological and economic features. According to Burić *et al*. [22], 'Žižak' is known as variety with middle and high yield (from 10 to 15 t/ha). Based on achieved data (Table 1) it is noticed that the lowest average bunch number per vine (10.46), yield per vine (2.02 kg) and per ha (6.48 t) was when 7 buds per vine was left. While the highest bunch weight (209.91 g), yield per vine (3.62 kg/vine) and yield per ha (11.61 t/ha) were achieved within the trial where 12 buds per vine were left. It is noticed (Table 1) that there are not significant differences in values of average number of bunches per vine, average bunch weight and yield per vine and per ha within yield when 14 and 18 buds per vine were left by mixed pruning (spurs and canes). This kind of winter pruning gives a huge number of bunches, an average yield per vine is not big, due to its relatively small average weight of bunch [24].

### *3.2 Grape and wine quality*

The results of chemical composition of grape must (sugar level, total acidity, pH value) and wine produced (alcohol, total acids, tartaric acid, pH value, total dry extract, total and free $SO_2$, anthocyanins content, total polyphenols content and sensory analysis) are shown in Table 2.

Within variety 'Kratošija', grape quality expressed through the sugar content, total acids and pH value was the best in grape must of 8 t/ha yield. Based on chemical and sensory analysis Kratošija wine produced of 8 t/ha grape also showed the best characteristics (alcohol - 13.49 vol%, total dry extract - 31.5 g/L and sensory analysis - 84.00 points). Based on results it can be concluded that these wines are more extractive as total dry extract content ranged from 30.0 to 31.5 g/L. The anthocyanins content (393 mg/L) was the highest also in wine of 8 t/ha. At yield of 15 t/ha grape must showed the lowest sugar level (21.2 %), and consequently produced wine contained the lowest total dry extract (30 g/L) and anthocyanins (244 mg/L).

Grape quality of 'Žižak' variety did not shown significant differences between all examined yields. It is noticed that the lowest sugar content (21.0%) was achieved in grape of 9 t/ha yield, while unexpectedly the highest (22.8 %) in grape of 12 t/ha yield. The optimal chemical (alcohol content - 14.20 vol%, total dry extract - 23.5 g/L) and sensory parameters - 86.25 points were achieved also in wine of 12 t/ha yield, while the lowest alcohol content (13.00 vol%) and sensory quality (80.50 points) were in wine of 9 t/ha yield.

## 4. Conclusions

- Based on obtained results of 'Kratošija' variety, it was concluded that the best quality of grapes and wines was achieved at yield of 8 t/ha (sugar content, alcohol and total dry extract), what is also confirmed by sensory analysis. Therefore, it can be concluded that lower yields grape of 'Kratošija' variety give better wine quality. Only in relation to the sensory quality are comparable wines of two yields (8 and 15 t/ha), but the content of anthocyanins at low yield was significantly higher.

**Table 2. Chemical composition of grape must and wine produced in relation to yield and variety**

| Yield of variety | Grape must | | | Wine | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sugar (%) | Total acidity (g/L) | pH | Alcohol (vol%) | Reducing sugars (g/L) | Total acidity (g/L) | pH | Total dry extract (g/L) | Tartaric acid (g/L) | Total $SO_2$ (g/L) | Free $SO_2$ (g/L) | Antho-cyanins (mg/L) | Total poly-phenols (g/L) | Sensory analysis (points) |
| **Kratošija** | | | | | | | | | | | | | | |
| **6** | 23.4 | 6.21 | 3.62 | 13.28 | 1.44 | 5.28 | 3.70 | 30.7 | 1.67 | 72 | 9 | 257 | 1.66 | 81.25 |
| **8** | 23.9 | 6.39 | 3.57 | 13.49 | 1.63 | 5.58 | 3.72 | 31.5 | 1.84 | 67 | 9 | 393 | 1.02 | 84.00 |
| **11** | 22.8 | 5.50 | 3.58 | 13.53 | 1.34 | 5.98 | 3.60 | 30.2 | 2.11 | 64 | 8 | 278 | 1.47 | 80.00 |
| **13** | 22.6 | 5.91 | 3.57 | 13.51 | 1.15 | 5.81 | 3.66 | 31.3 | 2.00 | 67 | 8 | 275 | 1.35 | 79.50 |
| **15** | 21.2 | 6.32 | 3.48 | 13.41 | 1.44 | 5.46 | 3.69 | 30.0 | 2.21 | 61 | 12 | 244 | 1.44 | 83.25 |
| **Žižak** | | | | | | | | | | | | | | |
| **6** | 22.3 | 5.29 | 3.35 | 14.07 | 1.63 | 7.22 | 3.32 | 23.2 | 3.96 | 78 | 13 | - | - | 86.00 |
| **8** | 22.0 | 5.70 | 3.38 | 13.80 | 1.34 | 7.35 | 3.29 | 22.2 | 4.55 | 58 | 5 | - | - | 82.25 |
| **9** | 21.0 | 6.87 | 3.30 | 13.00 | 0.86 | 8.22 | 3.19 | 26.1 | 4.15 | 65 | 8 | - | - | 80.50 |
| **10** | 22.3 | 6.65 | 3.36 | 13.83 | 1.25 | 7.52 | 3.23 | 23.2 | 4.25 | 66 | 10 | - | - | 81.25 |
| **12** | 22.8 | 6.00 | 3.38 | 14.20 | 1.34 | 7.49 | 3.28 | 23.5 | 3.52 | 67 | 9 | - | - | 86.25 |

- The optimal chemical (sugar content, alcohol and total dry extract) and sensorial parameters of 'Žižak' variety were achieved at the yield of 12 t/ha, but there weren't significant differences between all examined yields. With respect only to the sensory quality of wines produced are the most surprising results of the minimum and maximum yield with 86 points, while all other three load ratings between 80 - 82 points.

- Although achieved results are positive, it should be noted that data collected during one year are not sufficient to conclude which optimal load of grape gives the wine of the best quality. There is necessity to do continuously this kind of research. However, the most important is to get desirable style of wine, made of certain grape variety with the optimal yield that is influenced by many of factors.

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