CHARACTERIZATION OF GRAPE AND WINE QUALITY INFLUENCED BY TERROIR IN DIFFERENT ECOSYSTEMS FROM ROMANIA CULTIVATED WITH FETEASCĂ NEAGRĂ

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Abstract

Grapes and especially wine from same variety may be very different, depending on many factors. These attributes have the advantage that, different tastes, curiosities and demands of wine connoisseurs can be satisfied. The experiments concerning the influence of terroir on the grapes and wine quality in 'Fetească Neagră' variety were located in the main vineyards from western Romania (Minis-Maderat, Recas and Buzias-Silagiu). The aim of the research was to found the influence of the ecological resources, type of pruning, fruit loading and age plantation on grapes quality (sugar, acidity, must yield), but also on the wine quantity and quality (liters per hectare, alcohol concentration, organoleptic characteristics, anthocyanin concentration, acidity, full-bodied). Although belongs to the same variety, the resulted wines had different characteristics on most parameters analyzed. Recas wines are fruity; those from Buzias are more obvious full bodied, while those from Minis-Maderat have higher anthocyanin pigmentation. After results analyzing, it can be concluded that in all three areas of research, terroir allowed obtaining quality wines, but with different characteristics, each bearing the mark of the origin area.

Key words: acidity, grapes, sugar, terroir, wine.

INTRODUCTION

The soil, climatic and technological diversity in which the grapevine is cultivated have major impact on wine quality - even in the same variety - so that wines with certain quality and typicality can be obtained, that can satisfy a wide range of consumers (Gladstones, 2011). Quality cannot be achieved only through a harmonious combination of factors: soil-climate-soil-technology (Dobrei et al., 2016a). In red wines, the influence of terroir on quality is high, resulting in wines with different properties (body and balance, anthocyanin pigmentation, tannins etc. - Dobrei A. et al., 2010).

Wine texture qualities are essential in determining wine quality classes and are determined in accordance with wine tasting and typicity which reflects varietal origins (Dobrei et al., 2016a).

One of the most valuable red varieties is the 'Fetească neagră', considered by many scientists and consumers, the most valuable Romanian variety. However, although not highly advertised in last decades, through a proper technology and winemaking, remarkable results have been achieved (Dobrei et al., 2016b).

A harmonious correlation of the crop technology (fruit breeding, green pruning and training, optimum harvesting time), with the ecological resources and climatic conditions of the crop year, most often resulted in the 'Fetească neagră' grapes of high quality, without which it is not possible to obtain reference wines (Belda et al., 2017; Cichi et al., 2016).

A harmonious correlation of the crop technology (crop load, green pruning, favorable harvesting time) with the ecological resources of the area and with the climatic conditions, have often resulted in obtaining grapes of special quality in 'Fetească neagră' variety, without which it is not possible to obtain special wines (Rotaru et al., 2010; Rotaru et al., 2013).

MATERIALS AND METHODS

Resarch was carried out during 2016-2017 in four different locations: Buziaș-Silagiu, Recaș,

Miniş-Măderat and Mocrea vineyards. Mocrea was recognized from 1199 as wine-growing settlement, now part of Miniş-Măderat vineyards.

The complex influences of terroir - climate, soils, slope, and vineyard growing technology - on grapes and wine quality from 'Fetească neagră' variety was investigated.

For more accurate results, the experiments were located in vineyards with different characteristics (vine age, vine training system, crop load) placed on different soil types and land with various exposure to sunlight (Table 1). Research years were climatically different: 2017 has been marked by high temperatures and low rainfall, while 2016 was a warmer year and more rainfall, but without exceeding the normal.

Temperature associated with vineyard placement and soil, has strong control on ripening and then on grape and wine quality. Located not far away from each other, all three vineyards produced wine for long time. However, several geo-morphological variations which induce different micro-climatic conditions between vineyards affect the grapevine development and growth.

Grape maturity during ripening was determined by sugar concentration and titratable acidity, in the third decade of September in 2016 and second decade of September in 2017.

Grape samples were harvested from experimental plots from each vineyard in which the research was carried out.

After berries crushing, the samples of must were subjected to analyze for sugars and total acidity determination.

Sugar concentration (g/l) was measured using a digital refractometer at $20^{o}C$.

The acidity of the samples was performed by the titrimetric method by neutralizing the acidity of the samples with a known 0.1 M NaOH solution (F = 0.9527). The obtained results are expressed in g/l tartaric acid. Winemaking technology has not been the subject of our research, this being carried by a standard protocol specific to each vineyard. Wine analyses were done after finishing the winemaking process.

Total content of monomeric anthocyanins (cyanidin-3-glucoside equivalents / L sample) was calculated according to the following relation equivalents / L sample) and was calculated according to the following relation:

$$Anthocyani\ ns\ (mg/l) = \frac{(A \cdot MW \cdot DF \cdot 1000)}{\varepsilon \cdot L}$$

where: A = (A520 nm pH 1.0 - A700 nm pH 1.0) - (A520 pH 4.5 nm - A700 nm pH 4.5); MW = molecular weight of cyanidin-3-glucoside (449.2); DF = dilution factor; ε = molar absorbance of cyanidin-3-glucoside in acidic aqueous solution; L = optical path (1 cm).

The method of wine colour determination with the highest accuracy was done by the spectrophotometric method. This involves raising VIS spectra (in the visible wavelength: 380-720 nm) in reflectance or transmittance.

The sensory analysis was carried out in accordance with the Regulation of the Association of Authorized Tasters in Romania and according to the International Vine and Wine Office.

According to the OIV (International Vine and Wine Organization) quality assessment system, wine is assessed on three main characteristics and nine sub-characteristics, as well as a global assessment called harmony.

The main characteristics that were evaluated are: appearance (turbidity or haze, color), aroma, taste and mouthfeel (acidity, sweetness, bitterness, astringency, any new flavors or aromas perceived). The tasting was done by a five member group, under laboratory conditions, using tasting glasses, wines having a temperature of 18°C.

The rating was divided into the following categories, based on the average of the points received, obtained by adding the five notes and dividing them to five.

The score obtained was as follows: excellent (full body); very good (medium to full body); good (medium).

Results concerning the influence of terroir from experimental variants on 'Fetească neagră' grapes production and quality (sugar, acidity, must yield), but also on the wine quantity and quality (wine yield per hectare, alcohol by volume, wine sensory properties and texture, anthocyanin pigmentation) were statistically analyzed. All experiments were repeated three times.

Table 1. Experimental variants

Vineyard	Soil type	Exposure to sunlight	Vine age (years)	Vine training system	Crop load (buds/vine)
V$_1$ - Recaș	Reddish brown	S-E	20	Guyot	20
V$_2$ - Buziaș	Luvisols Podzoluvisols	E	12	Cazenave	25
V$_3$ - Mocrea	Rendzina soils	S-E	6	Cazenave	16
V$_4$ - Miniș	Rendzina soils	S	15	Guyot	18

Average and standard deviations of the data were calculated. The average comparison test and the Fisher test (LSD) were applied to compare the results of must and wine characteristics. The confidence interval was set at 5%. For all statistical tests, the SPSS (SPSS Inc., Chicago, IL) for Windows, version 22.0 was used.

RESULTS AND DISCUSSIONS

Year 2016 was normal for grapevine growing, without extremely favourable climatic conditions due to the high rainfall in July, August and September.
Grape yields were high, close to the maximum crop potential, especially in the Buziaș and Recaș vineyards (Table 2). In these areas the soil fertility correlated with rainfall and crop load increased the production to 11375 kg/ha at

Buziaș and 10758 kg/ha at Recaș. In Miniș and Mocrea vineyards, yields were lower compared to those from Buziaș and Recaș, but in normal limits for 'Fetească neagră' variety. In these areas, rendzina soils are considered to have limited potential for grapevine production.
Concerning the grapes sugar content, results were good considering the climatic conditions variation during the year; the highest sugar content was recorded in Mocrea vineyard, followed by results from Miniș and Recaș. Higher sugar concentrations recorded in the Mocrea and Miniș areas are statistically significant, as result of the rendzina soils properties which lowered the crop load. Regarding the must yield, differences between investigated variants are insignificant, with limits between 75-79%, values considered normal.

Table 2. The influence of terroir on production quality during 2016

Experimental variant	Production (kg/ha)	Sugars (g/l must)	Acidity (g/l H$_2$SO$_4$)	Must yield (%)	Difference to control (sugars g/l)	Significance
V$_1$ - Recaș	10758	209	4.9	79	-4	-
V$_2$ - Buziaș	11375	198	5.2	78	-15	00
V$_3$ - Mocrea	8773	226	4.6	75	+13	**
V$_4$ - Miniș	9145	218	4.8	76	+5	*
Mean (Mt)	10013	213	4.8	77	-	-
DL	5% - 4.93		1% - 10.17		0.1% - 18.32	

During 2017 climate conditions were high temperatures and low rainfall, with positive influence on grape quality, but with lower yields than the previous year (Table 3). The yields ranged between 10873 kg/ha at Buziaș

and 8152 kg/ha at Mocrea. The sugar concentration increased in grape berries from all four vineyards experimental plots, ranging from 249 grams per liter in Mocrea and 218 grams per liter in Buziaș.

Table 3. The influence of terroir on production quality during 2017

Experimental variant	Production (kg/ha)	Sugars (g/l must)	Acidity (g/l H$_2$SO$_4$)	Must yield (%)	Difference to control (sugars g/l)	Significance
V$_1$ - Recaș	10120	228	4.7	78.0	-4	-
V$_2$ - Buziaș	10873	218	5.0	76.0	-14	00
V$_3$ - Mocrea	8152	249	4.4	73.0	+17	***
V$_4$ - Miniș	8207	233	4.6	74.0	+1	-
Mean (Mt)	9338	232	4.6	75.2	-	-
DL	5% - 4.03		1% - 9.24		0.1% - 16.92	

Table 4. The influence of terroir on production quality during 2016 - 2017

Experimental variant	Production (kg/ha)	Sugars (g/l must)	Acidity (g/l H$_2$SO$_4$)	Must yield (%)	Difference to control (sugars g/l)	Significance
V$_1$ - Recaș	10439	219	4.8	78.5	-4	-
V$_2$ - Buziaș	11124	208	5.1	77.0	-15	00
V$_3$ - Mocrea	8463	238	4.5	74.0	+15	**
V$_4$ - Miniș	8676	226	4.7	75.0	+3	-
Mean (Mt)	9676	223	4.7	76.1	-	-
DL	5% - 4.64		1% - 9.43		0.1% - 17.20	

Due to the climate variability from both years, for the accuracy of the results is presented an average of the two years of research in Table 4.

Regarding the production, were recorded average and high values for this variety in correlation with climatic conditions, soil type and crop loads. The smallest productions were obtained on less fertile rendzina soils and on lower crop loads from Mocrea and Miniș vineyards. The more fertile soils from Buziaș and Recaș, in correlation with higher crop loads, create a positive effect on the average production potential of this variety and higher yields were recorded.

With respect to grapes quality, all four grape-growing areas have proven to be very favourable to 'Fetească neagră' variety, sugar concentration recorded in grape berries being high or very high.

Rendzina soils correlated with the favourable exposure to sunlight and smaller crop loads, favoured the accumulation of very high amounts of sugar (238 g/l) in the grape must from Mocrea and 226 g/l in grape must from Miniș. Very good grape quality was also recorded in Recaș vineyards, where the reddish-brown soil associated with the southern exposure of the vine rows and a moderate crop load on long spurs/canes, favoured the accumulation of 219 g/l sugar.

In Buziaș vineyards, the luvisols in correlation with a higher crop load on short canes favoured the accumulation of medium amounts of sugars in must (208 g/l), which are lower compared to the other three grape-growing areas. This value for the sugars is the only one with negative statistical significance compared to the average results found during the research.

During 2016, the wine yield per hectare varied between 8 531 l/ha at Buziaș and 6 404 l/ha at Mocrea vineyards (Table 5). The more fertile soils from Buziaș and Recaș favoured a higher amount of wine per hectare compared with less fertile rendzina soils from Miniș and Mocrea. In contrast, rendzina soil provided higher alcohol concentration and higher anthocyanin content compared to fertile soils.

In 2017, high temperatures and low rainfall decreased the amount of wine yield per hectare in all grape-growing areas investigated, but instead had a positive influence on alcohol concentration and anthocyanin content. This year, the smallest wine yields per hectare were produced on rendzina soils from Miniș (5 826 l/ha) and Mocrea (5 787 l/ha) respectively (Table 6).

Concerning the sensory wine properties, in both years, wines were marked by their clarity, colour and body, with a plus for those produced in 2017 (Table 7). These wines, by proper storing and vintage can become reference wines with real chances of assertion in the future national or international wine contests.

Table 5. The influence of terroir on wine quality during 2016

Experimental variant	Wine yield (l/ha)	Alcohol (%)	Anthocyanin (mg/l)	Sensory properties qualities		
				Limpidity	Color	Body
V$_1$ - Recaș	8176	12.0	233.0	Clear	Red ruby	Medium to full
V$_2$ - Buziaș	8531	11.5	218.0	Clear	Red ruby	Medium
V$_3$ - Mocrea	6404	13.1	236.0	Limpid	Red ruby	Full
V$_4$ - Miniș	6675	12.7	238.0	Limpid	Dark red	Full
Mean (Mt)	7446	12.3	231.2	-	-	-

Table 6. The influence of terroir on wine quality during 2017

Experimental variant	Wine yield (l/ha)	Alcohol (%)	Anthocyanin (mg/l)	Sensory properties qualities		
				Limpidity	Color	Body
V_1 - Recaș	7590	13.2	243	Clear	Red ruby	Medium to full
V_2 - Buziaș	7937	12.7	224	Clear	Red ruby	Medium
V_3 - Mocrea	5787	14.5	245	Limpid	Dark red	Full
V_4 - Miniș	5826	13.5	248	Limpid	Dark red	Full
Mean (Mt)	6785	13.4	240	-	-	-

Table 7. The influence of terroir on wine quality during 2016 -2017

Experimental variant	Wine yield (l/ha)	Alcohol (%)	Anthocyanin (mg/l)
V_1 - Recaș	7883	12.6	238.0
V_2 – Buziaș	8234	12.1	221.0
V_3 - Mocrea	6096	13.8	240.5
V_4 – Miniș	6251	13.1	243.0

During the research made by Artem et al. (2014) on four red wine varieties, they found in 'Fetească neagră', highest values for acidity (7.72 g/l), and for anthocyanins (325.92 mg/l). The alcohol concentration found in the same research (13.55%), was quite similar with the average of 'Fetească neagră' from our investigation (13.4%). Mori et al. (2007) mention in their research that temperature over 35^0C decreased the anthocyanin content in red grape berries. In a study carried out during 2014-2015, Coldea et al., found out in 'Fetească neagră' variety a lower total acidity, between 3.28 and 3.72 mg/l, and alcohol content with limits between 11.78 and 13.70%. In the research carried out by Artem et al. (2015) in Murfatlar vineyards on 'Fetească neagră' variety, they found out close results for alcohol concentration (12.8 - 13.4%), higher values for acidity (6.33 - 5.77 mg/l) and for anthocyanins (409 - 531 mg/l).

Wine components are much or less correlated with each other. Alcohol concentration (%) from 'Fetească neagră' during 2016-2017 is highly and negatively influenced by the wine yield (l/ha) and by the crop load. The higher the crop load, the lowest is the alcohol concentration in the wine. The wine yield is strong influenced by the crop load. The anthocyanin content in the wine is low correlated with crop load, while alcohol concentration in the wine is negative correlated with the anthocyanin content and crop load (Table 8). Strong positive correlation was recorded between wine yield and crop load.

Table 8. Correlation between wine yield, anthocyanin and crop load in 'Fetească neagră' variety, during 2016-2017

		Wine yield (l/ha)	Alcohol (%)	Anthocyanin (mg/l)	Crop load (buds/vine)
Wine yield (l/ha)	7883	1	-0.936946137	0.545198709	0.989044201
Alcohol (%)	12.6	-0.936946137	1	-0.217855545	-0.978270352
Anthocyanin (mg/ l)	243	0.545198709	-0.217855545	1	0.415475039
Crop load (buds/vine)	20	0.989044201	-0.978270352	0.415475039	1

Table 9. Variability in Fetească neagră variety traits during 2016-2017, in research locations

	Wine yield (l/ha)	Alcohol (%)	Anthocyanin (mg/l)	Crop load (buds/vine)
Mean	6860.33	13.00	233.17	19.67
Standard Error	688.28	0.49	6.13	2.73
Standard Deviation	1192.15	0.85	10.61	4.73
Minimum	6096.00	12.10	221.00	16.00
Maximum	8234.00	13.80	240.50	25.00
CV %	17.37.00	6.57	4.55	24.05

As Jackson and Lombard (1993) said, the quality of the wine "is not easy to define", but it is sure that a good wine must have good taste, special aroma and sensory properties above average for each type of wine.

From Table 9 can be found that the highest variability was registered in the crop load (CV=24.05%), with high level of dispersion around the mean. Low coefficient of variation of 4.55% show that anthocyanins content in 'Fetească neagră' wine, is uniform during research years (2016-2017). In the same time anthocyanins is uniform in vineyards where researches were carried out. Low coefficient of correlation for alcohol concentration (CV=6.57), show the versatility and high adaptability of 'Fetească neagră' variety in different ecosystems and terroir from the west of Romania. Studding the Montenegrin autochthonous red varieties, Košmerl et al. (2013) concluded that poor correlation was found among yield and quality parameters. In their research, lower crop yield didn't result in higher levels of anthocyanins, polyphenols, or sugars.

CONCLUSIONS

'Fetească neagră' variety proved to be a well-adapted in all four grape-growing areas, both grapes and wine being of very good quality.

The different climatic conditions during the years, different soil types from one area to another, the crop load and vine age, were factors that influenced the quality of grapes and wine and highlighted the particular adaptability of this variety.

Variety gives good results both on deep and fertile soils which ensure acceptable production and both on thin and rocky soil type like rendzina soil, on which are highlighted the variety quality potential.

Research results are confirmed by other previous research (Dobrei et al., 2010), according to which 'Fetească neagră' produce pigmented wines with the highest content in anthocyanins on rendzina soils in Miniș and Mocrea vineyards, followed by reddish brown soils from Recaș and Buziaș.

Linking of growing technology with the soil type and environmental resources of the area, make it possible to achieve special wine that ensures customer demands through the special sensory qualities, typicity and authenticity.

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