Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. XIII, 2024
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

TRENDS IN "FETEASCĂ REGALĂ" GRAPES YIELD AND SUGAR CONTENT IN SITE SPECIFIC CLIMATE

Octav-Mihai CISMAȘIU[1], Ioan OROIAN[1], Marcel DÎRJA[2], Cristian IEDERAN[1], Antonia ODAGIU[1]

[1]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture, 3-5 Calea Manastur, Cluj-Napoca, Romania
[2]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Silviculture and Cadastre, 3-5 Calea Manastur, Cluj-Napoca, Romania

Corresponding author email: antonia.odagiu@usamvcluj.ro

Abstract

In this article we analyse the evolution of the grapes yield and their sugar content belonging to "Fetească Regală" vineyard variety cultivated in climatic conditions of Transylvanian region, Romania, covering the time period 2020–2022. In each experimental year, daily temperatures and precipitations were recorded during the grapevine vegetation period. Grapevine yield and sugar content was recorded at the end of each vegetation period. Averages were calculated yearly and by entire experimental period. Descriptive statistics and multi regression approach were implemented to calculate de averages, dispersion parameters, significance of differences, and relationships between the climatic factors and production traits. Overall datasets concerning grapes yields and their sugar content expressed a normal distribution. Our study emphasizes that precipitations have low influence on grapes yields and their sugar content, while temperature is positively associated with both above mentioned quantitative traits. When expressed by experimental years, increased temperatures led to higher yields and sugar content, significant differences are reported among yearly values.

Key words*: precipitations, production, temperature, vineyard, quantitative traits.*

INTRODUCTION

The yield of "Fetească Regală" grapes and the sugar content are significantly influenced by the climatic conditions specific to the wine-growing site. The variety "Fetească Regală" is known to produce aromatic and pleasant wines, and the aspects related to the yield and the chemical composition of the grapes are essential for the final quality of the wine (Miroševic & Karoglan-Kontić, 2015; Ollat et al., 2002).

The variety "Fetească Regală" grows well in a temperate climate, with mild winters and warm, but not excessively hot, summers. Well-drained and moderately fertile soils are preferred, as they allow adequate root development and ensure good nutrient absorption. The variety "Fetească Regală" thrives in a moderate temperature range, with warm summers and mild winters (Colibaba et al., 2024).

Grape yields can vary depending on many factors, including vineyard management, vine health, and weather conditions during the growing season (Borca et al., 2019, Bărbulescu et al., 2022). The site-specific climate has a major impact on the ripeness of the grapes and their sugar content. Temperature is a key factor in the development of grapes and the accumulation of sugar in the fruit (Block et al., 2013; Bucur et al., 2019; Carroquino et al., 2020; Van Leeuwen & Darriet, 2016; Ollat et al., 2002).

High temperatures during the growing season can accelerate the ripening process of the grapes, causing a faster accumulation of sugar. However, temperatures that are too high can lead to water stress and loss of acidity in the grapes, which can negatively affect the quality of the wine.

The amount and distribution of rainfall are essential for the healthy development of the vines and the production of quality grapes. Excessive rainfall can cause the grapes to crack and promote fungal diseases such as mold and rot. Conversely, a lack of rainfall can lead to water stress, which can reduce the size and quality of grapes and negatively influence their sugar content. Temperature variations between day and night can significantly influence the quality of the grapes. Cooler nights can help

maintain acidity in the grapes, while warm days favor sugar build-up and flavor development (Hannah et al., 2013; Mendez- Costabel et al., 2014; Spayd et al., 2002).

Vine management techniques such as the proper administration of fertilizers and phytosanitary treatments can significantly influence grape yield and quality. Proper management can help maintain a healthy balance between vegetative growth and grape development.

The aim of the present study is to emphasize the "Fetească Regală" grape yield and sugar content function of specific climatic conditions of Geaogiu area, Hunedoara County, characterized by appropriate environmental conditions for vineyard development.

MATERIALS AND METHODS

The experiments took place during the period 2021-2022, respectively in two experimental years, in Geoagiu Basin, Hunedoara County, according to a bifactorial experiment (2 x 3), in randomized blocks, with different graduations, the factors being represented by the year experimental with its two graduations, respectively 2021 and 2022 and the phytosanitary treatment scheme with the 3 graduations, represented by the untreated control experimental variant and the experimental variants I and II treated according to different schemes.

Three repetitions were performed for each experimental variant. For each experimental variant, 8 treatments were applied. The experimental area, which covers an area of 3600 m^2, was divided into plots (1200 m^2 each plot), corresponding to the 3 experimental variants. Phytosanitary treatment was applied function of vegetation period with phytosanitary products homologated in Romania (https://aloe.anfdf.ro/): 1 - control, where no treatments were applied; 2 - complex treatment scheme, which includes 12 sprinkles (with a mixture of 12 active substances), and 3 - medium treatment scheme with 8 sprinkles (with a mixture of 11 active substances).

Fertilization administered to the soil was carried out with NPK complex mineral fertilizer (16-16-16). On each plot (40 m x 30 m), the distance between the stumps is equal to 1 m (1.5 m on the edge), and between the rows 1.5 m. On each of the 11 rows (2 m on the edge) there are 25 rows cones, of which, on average, 21 cones per fruit.

The biological material used in the present study is represented by the "Fetească Regală" vine variety, which has an important tradition in culture at the level of the Geoagiu Basin area and produces white grapes. The grape variety "Fetească Regală" (syn. Königstraube, Dănășană, Kirayleanka, Galbenă de Ardeal) is a hybrid between the Fetească albă and Francușe varieties. This variety is part of the category of semi-aromatic varieties and has a good capacity to exploit the vast majority of soil types (https://www.horticultorul.ro/vita-de-vi e/fetea sca -regala/).

The environmental temperature and precipitations data were obtained from the meteorological station iMETOS 3.3 placed in the experimental field, which performs daily recordings. Grapes yields and sugar contents data were collected, by weighing and laboratory analysis, respectively. The sugar content was realized refractometrically.

In order to statistically process the raw data, the program STATISTICA v.8.0 for Windows was used, both for the monitored environmental factors and for the grapes yield and sugar content of the grapes.

The "Descrtiptive statistics" program component was used with the aim of calculating the following parameters of the basic statistics: mean, standard deviation, coefficient of variability, values of maximum and minimum.

With the help of the "t - test independent by variables" component of the program, the significance of the differences between the means was calculated, at the significance thresholds of 5%, 1% and 0.1% (Merce & Merce, 2009).

With the help of the components of the "Multiple Regression" program, the multiple correlations, the related coefficients of determination and the regression lines were calculated, which highlighted the interdependencies between the characteristics analyzed and the climatic factors. The component of the "Multivariate Exploratory Techniques" program, through its option Cluster analysis, was used to rank the productions and the content of the sugar, depending on the experimental variant.

RESULTS AND DISCUSSIONS

Analyzing the climatic indices, we find that in 2022 the averages of the environmental parameters characterized by growing season significantly increased compared to 2021. By entire experimental field, the temperature increased by 8.57%, while relative humidity and precipitations decreased by 16.31%, and 19.72%, respectively (Table 1).

Table 1. The basic statistics for environmental temperature, air humidity and rainfall regimen in experimental site located in Geoagiu area, 2021-2022

Issue	Year	N	X	S	Minimum	Maximum	s
Temperature (°C)	2021	183	18.04[a]	3301.80	6.20	24.70	3.44
Air humidity (%)		183	72.39[c]	13250.80	39.60	98.10	11.36
Precipitations (mm)		96	4.87[e]	468.00	0.50	25.00	5.28
Temperature (°C)	2022	183	19.73[b]	3538.00	7.00	30.20	9.31
Air humidity (%)		183	60.53[d]	11077.00	28.00	90.00	13.16
Precipitations (mm)		94	3.91[f]	368.00	0.50	25.00	4.82

N - number of days; X - mean; S - sum; s - standard deviation; the differences between any two yield averages are significant, if their values are followed by letters, or groups of different letters.

The average grapes' yield recorded statistically significant variation, function of phytosanitary treatment and climatic conditions, in a wide range. The lowest average production (0.53 t/ha) corresponds to no phytosanitary treatment, lowest average temperature and highest relative humidity, and precipitations of the growing period, and largest (0.93 t/ha) to the Ist treatment scheme applied in conditions of the year 2022, characterized by highest average temperature and lowest relative humidity and precipitations, reported to the growing season of the entire experimental period (Tables 1, and 2). Higher productions and evolutions according to temperature and precipitations regimes are reported by Bădulescu et al. (2020), who in climatic conditions of Ștefănești, Arges County obtained an average "Fetească Regală" grapes' production of 17.32 t/ha in 2019, and 18.71 t/ha, in 2020, growth in the same conditions, in two successive years characterized by higher temperature, and lower rainfall regimen in 2020, compared with 2019. Similar productions with majority of those reported in this study, were obtained by Băjenaru et al. (2022), 14.39 t/ha in 2020, and 14.48 t/ha, in 2021, in pedo-climatic conditions of Dăbuleni, Dolj County, with a light increase reported in 2021, year characterized by higher temperature and lower rainfall regimen, compared with 2020.

Table 2. The basic statistics for the yield recorded in Fetească Regală grapes variety, when different phytosanitary schemes are applied, 2021-2022 (t/ha)

Experimental variant	Year	N	X	Minimum	Maximum	s	CV
I	2021	10	10.20[ab]	0.40	0.83	0.11	20.75
II		10	15.01[ab]	0.65	0.90	0.09	11.53
III		10	12.32[a]	0.50	0.80	0.07	10.93
I	2022	10	11.74[b]	0.55	0.80	0.08	13.11
II		10	17.91[b]	0.70	1.05	0.14	16.86
III		10	15.21[b]	0.50	0.90	0.15	18.98

I - control not treated; II - Ist pattern of phytosanitary treatment; III - IInd pattern of phytosanitary treatment; X - arithmetic mean (%); s - standard deviation (%); CV - variation coefficient (%); the differences between any two yield averages are significant, if their values are followed by letters, or groups of different letters.

Concerning sugar content, we find the same evolutions as for grapes' yield, function of phytosanitary treatment and climatic conditions, but statistically significant differences are reported only between control, and sugar content corresponding to Ist treatment scheme, by each year. In this case, low variations are recorded, and they frame within 176.17 g/L-198.50 g/L (Table 3). Bădulescu et al. (2020), in climatic conditions of Ștefănești, Arges County reported similar "Fetească Regală" grapes sugar content, corresponding to 2019 (230 g/L) and 2020 (230.08 g/L), but higher compared to results emphasized in this study. Băjenaru et al. (2022), reported an average sugar content of 178 g/L by a 9 years period (2013-2020), in Fetească regală grapes, in pedo-climatic conditions of Dăbuleni, Dolj County, which is similar to majority of of those reported in this study.

Table 3. The basic statistics for the sugar content recorded in Fetească Regală grapes variety, when different phytosanitary schemes are applied, 2021-2022 (g/L)

Experimental variant	Year	N	X	Minimum	Maximum	s	CV
I	2021	10	176.17^{ab}	160.00	183.00	5.88	3.34
II		10	192.00^{b}	170.00	200.00	5.05	2.63
III		10	180.27^{ab}	173.00	192.00	8.31	4.61
I	2022	10	179.33^{ab}	167.00	184.00	7.47	4.17
II		10	198.50^{b}	189.00	205.00	4.07	2.05
III		10	189.00^{ab}	178.00	200.00	8.24	4.35

I - control not treated; II - Ist pattern of phytosanitary treatment; III - IInd pattern of phytosanitary treatment; X - arithmetic mean (%); s - standard deviation (%); CV - variation coefficient (%); the differences between any two yield averages are significant, if their values are followed by letters, or groups of different letters.

Trials conducted in Dealul Silagiului, Timiș County during 2018-2019, by Borca et al. (2019) to control the efficacy of different phytosanitary treatment schemes on "Fetească Regală" grapes yield and sugar content emphasizes similar evolutions like our study, with best performances when complex scheme of treatment was applied, and lowest for minimal treatment scheme. Their results show lower values of grapes yield, framing in the range of 11.42 t/ha-14.85 t/ha, but higher sugar content corresponding to complex scheme of phytosanitary fight, framing in the range of 176 g/L-203 g/L, compared with those reported by our study.

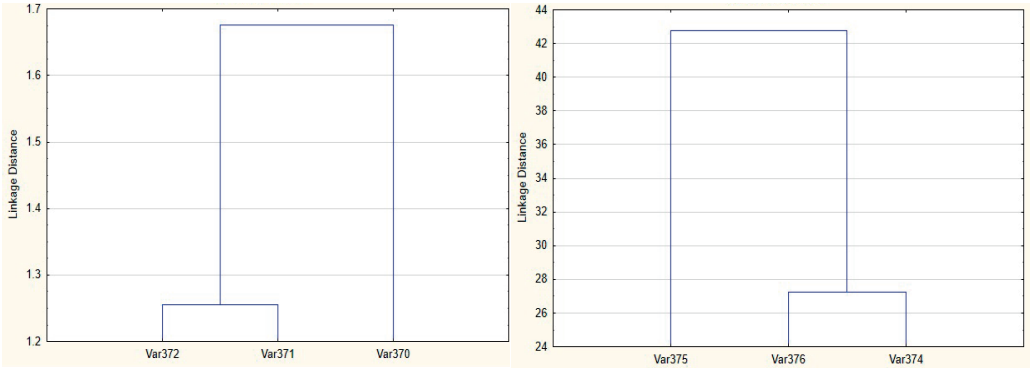
The multiple regression analyze was conducted to predict both grapes' yield and sugar content based on the evolutions of environmental temperature, relative humidity, and precipitations recorded in experimental site. The increase of grapes' yield and sugar content function of phytosanitary treatments is multiple corelated with analyzed environmental parameters in a strong manner as the values of multiple correlations coefficients show. They frame within the ranges of R = 0.661 (accounting for 43.7% of variance) corresponding to moderate treatment scheme - 0.778 (accounting for 60.5% of variance) corresponding to control, for grapes' yield (Table 4), and within the ranges R = 0.512 (accounting for 34% of variance) corresponding to moderate treatment scheme, and R = 0.623 (accounting for 38.8% of variance) corresponding to control without treatment, for sugar content (Table 5).

Very strong simple correlation is reported by Cogato et al. (2019) between relative humidity in June (R = 0.939 accounting for 88.2% of variance) and sugar content, for several withe, grey and red wines growth in North-East of Italy.

Table 4. The relationship between Fetească Regală grapes yield environmental temperature (°C), relative humidity (%) and precipitations (mm), 2021-2022

Experimental variant	Year	R	R^2	Regression line
I	2021	0.778	0.605	Y = 1.387 + 1.143X1 – 0.378X2 – 1.036X3
II		0.680	0.462	Y = 1.875 + 0.843X1 – 0.234X2 – 0.643X3
III		0.661	0.437	Y = 1.346 + 0.799X1 – 0.130X2 – 0.711X3
I	2022	0.749	0.561	Y = 2.178 + 1.265X1 – 0.318X2 – 1.499X3
II		0.695	0.483	Y = 3.603 + 0.904X1 – 0.219X2 – 0.639X3
III		0.662	0.438	Y = 1.875 + 0.843X1 – 0.234X2 – 0.743X3

Analysing the dendrogram obtained for the grapes yields, we find two clusters. One is made of two branches and corresponds to experimental variants, with highest yields, and the other with a single branch, corresponding to control yield, which is lower compared to experimental yields (Figure 1a). The dendrogram corresponding to sugar content also has two clusters (Figure 1b). One corresponds to sugar content obtained when the first treatment scheme is applied, which is the highest by entire experiment, and the second with two branches corresponding to control and second treatment scheme.



a. The yield b. The sugar content

Figure 1. The cluster analysis for grape yields and sugar content
(Var 370 - control; Var 371 - 1st experimental scheme; Var 372 - 2nd experimental scheme; Var 374 - control; Var 375 - 1st experimental scheme; Var 376 - 2nd experimental scheme)

These results show that grapes yield corresponding to both experimental schemes are similar, but different compared with control, much higher in our case, while the first experimental scheme led to a much higher sugar content compared with control and second experimental scheme.

Bucur and Dejeu (2014) reported moderate to strong simple positive correlations between average summer temperature on one hand, yield (R = 0.549 accounting for 30.2% of variance) and sugar content (R = 0.554 accounting for 30.8% of variance), for "Fetească Regală" variety growth in Bucharest - Băneasa areal.

They also reported a negative strong correlation between sum of precipitations in spring and grapes' yield (R = -0.723 accounting for 52.3% of variance).

Table 5. The relationship between Fetească Regală grapes sugar content, and environmental (°C), relative humidity (%) and precipitations (mm), 2021-2022

Experimental variant	Year	R	R^2	Regression line
I	2021	0.623	0.388	Y = 133.864 + 0.489X1 – 0.123X2 – 0.201X3
II		0.525	0.346	Y = 191.776 + 0.323X1 – 0.026X2 – 0.153X3
III		0.541	0.366	Y = 184.945 + 0.387X1 – 0.029X2 – 0.161X3
I	2022	0.602	0.362	Y = 102.409 + 0.517X1 – 0.123X2 – 0.229X3
II		0.512	0.340	Y = 238.169 + 0.315X1 – 0.091X2 – 0.129X3
III		0.535	0.354	Y = 183.621 + 0.382X1 – 0.094X2 – 0.180X3

According to our analyse, the largest grapes' yields and sugar content corresponds in both experimental years to the phytosanitary complex scheme (I), if no influence of environmental factors would be considered. As regression lines show, in all cases, temperature positively influences both grapes' yields and sugar content, while precipitations and relative humidity contribute to their decrease. When the control scheme is applied, the influence of all environmental parameters is more consistent compared to that observed as corresponding to the other schemes of treatment in sugars' yield, and slightly superior for sugar content (Tables 4 and 5). It suggests that the application of phytosanitary treatments reduces, to some extent, the dependence of grapes' yields of environmental factors influence.

CONCLUSIONS

The results of our study show that both climatic conditions expressed by environmental temperature, relative humidity, and precipitations and phytosanitary treatments are factors that significantly affects the grapes' yield and sugar content, but not with at same extent. The lowest average yield and sugar content correspond to no phytosanitary treatment, lowest average temperature and highest relative humidity, and precipitations expressed by the growing period, and highest to the complex

phytosanitary treatment (Ist experimental scheme) in conditions of the year 2022, characterized by highest average temperature and lowest relative humidity and precipitations. For both analyzed traits (grapes' yield, and sugar content), temperature positively influences their increase, while precipitations and relative humidity has a negative influence.

ACKNOWLEDGEMENTS

This study was supported by funds from the National Research Development Projects to finance excellence (PFE)-14/2022–2024 granted by the Romanian Ministry of Research and Innovation.

REFERENCES

Bădulescu, A., Sumedrea, D.I., Florea, A., Onache, A., Tănase, A. (2020). Influence of climate factors on yield and quality of some vine cultivars from the Ștefănești Center. *Romanian journal of Horticulture 1*(1), 149-156. DOI 10.51258/RJH.2020.20.

Bărbulescu, I.D., Matei, P.M., Frîncu, M., Baniță, C.D, Teodorescu, R.I., Tudor, V., Dumitrache, C. (2022). Tămâioasă Românească and Busuioacă de Bohotin grapes - valuable sources for wine production, *Scientific Papers. Series B, Horticulture, LXVI*(2), 171 – 176.

Block, A., Sparks, T.H., Estrella, N., Menel, A. (2013). Climate-Induced Changes in Grapevine Yield and Must Sugar Content in Franconia (Germany) between 1805 and 2010. *PLoS ONE, 8*(7), e69015. https://doi.org/10.1371/journal.Po ne.0069015.

Borca, F., Nan, R.D., Nistor, E., Dobrei, A. (2019). Effect of different phytosanitary treatment schemes on the yield and quality of some wine grape varieties. *Journal of Horticulture, Forestry and Biotechnology, 23*(4), 8-13.

Bucur, G.M., Cojocaru, G.A., Antoce A.O. (2019), The climate change influences and trends on the grapevine growing in Southern Romania: A long-term study, *BIO Web Conf., 15,* 01008, https://doi.org/10.1051/bioconf/20191501008.

Bucur, G.M., Dejeu, L. (2014). Influence of climate variability on growth, yield and quality of grapes in the south part of Romania. *Scientific Papers, Series B, Horticulture, LVIII*, 133-138.

Carroquino, J., Garcia-Casarejos, N., Gargallo, P. (2020). Classification of Spanish wineries according to their adoption of measures against climate change. *J. Clean. Prod.*, *244*, 142–155.

Cogato, A., Meggio, F., Pirotti, F., Cristante, A., Marinello, F. (2019). Analysis and impact of recent climate trends on grape composition in north-east Italy, *BIO Web of Conferences,* 04014, DOI:10.10 51 /bio conf/ 20191304014.

Colibaba, L.C., Bosoi, I., Puşcalău, M., Bodale, I., Luchian, C., Rotaru, L., Cotea, V.V. (2024). Climatic projections vs. grapevine phenology: a regional case study. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 52*(1), 13381. https://doi.org/10.15835/nbha52113381.

Hannah, L., Roehrdanz, P.R., Ikegami, M., Shepard, A.V., Shaw, M.R., Tabor, G., Zhi, L., Marquet, P.A., Hijmans, R.J. (2013). Climate change, wine, and conservation. *Proc. Natl. Acad. Sci. USA*, *110*, 6907–6912.

Mendez-Costabel, M., Wilkinson, K., Bastian, S., Jordans, C., Mccarthy, M., Ford C., Dokoozlian, N. (2014). Effect of winter rainfall on yield components and fruit green aromas of Vitis vinifera L. cv. Merlot in California. *Aust. J. Grape Wine Res, 20*, 100– 110.

Merce, E., Merce, C.C., (2009). *Statistics – consecrated paradigms and complementary paradigms.* Academic Pres Publishing House, Cluj-Napoca, pp. 457.

Miroševic, N., Karoglan-Kontić, J. (2008). *Viticulture*. Faculty of Agriculture, Zagreb.

Ollat, N., Diakou-Verdin, P., Carde, J., Barrieu, F., Gaudillère J., Moing, A. (2002). Grape berry development: a review, *J. Int. Sci. Vigne Vin, 36*, 109-131.

OIV (2009). Descriptor List for Grape Varieties and Vitis species, 2nd edition. http://oiv.int. (Accessed: 26.01.2024).

Spayd, S., Tarara, J., Mee, D., Ferguson, J. (2002). Separation of sunlight and temperature effects on the composition of Vitis vinifera cv. Merlot berries. Am. *J. Enol. Vitic., 53*, 171-182.

Van Leeuwen, C., Darriet, P. (2016). The Impact of Climate Change on Viticulture and Wine Quality. *J. Wine Econ.*, *11*, 150–167.

https://aloe.anfdf.ro/(Accesed: 24.01.2024).

https://www.horticultorul.ro/vita-de-vi e/feteasca -regala/ (Accesed: 24.01.2024).