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THE INFLUENCE OF THE ROOTSTOCK PARTNER FROM THE GRAFTING COMBINATION ON THE QUANTITY AND QUALITY OF GRAPE PRODUCTION OF THE FETEASCĂ NEAGRĂ VARIETY IN THE DEALU MARE VINEYARD

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Abstract

The rootstock exerts an important influence on the quality of the grapes, affecting the level of production through the vigor given to the vinifera variety. The research was carried out between 2020 and 2024, in a plantation with the Feteasc neagră variety grafted on rootstocks: 125AA, 2C, RG, 71C, SO4-4, 5BB, 140 Ru, 57D, 26C. Compared to the average (2020-2023), grape production in 2024 decreased by +1.117 kg/vine in the case of SO4-4 rootstock and by 0.464 kg/vine in the RG rootstock. The multiple comparison between rootstocks indicates that the 57D, 71C and 2C rootstocks achieved statistically assured positive production differences compared to the 125AA, 26C and RG rootstocks. Due to the accentuated hydric deficit and a high heliothermic regime characteristic of 2024, the concentration of the sugars varied between 262.9 g/l tartric acid at rootstock 57 D and 241.7 in the case of rootstocks 2C, RG, 26 C and SO4-4, to the detriment of the total acidity with variations between 3.9 g/l tartaric acid (57 D) and 5.7 g/l tartaric acid (125 AA and 2 C).

Key words*: extractible anthocyanins; grafting; polyphenols;* r*ootstocks; total anthocyanins.*

INTRODUCTION

Grafting is an essential practice in viticulture, significantly influencing the growth, yield and quality of grape production. The choice of rootstock plays a crucial role in determining the vine's vigor, resistance to environmental stress and the accumulation of essential compounds in the grapes. This study aims to evaluate the impact of different rootstocks on the quantity and quality of grape production of the Feteasc Neagră variety, analyzing the physiological mechanisms by which the rootstock influences the absorption of water and nutrients, the changes on the vigor of the stump and its adaptability to the conditions of biotic and abiotic stress.

The research was conducted over several growing seasons, looking at key parameters such as vine yield, sugar content, total acidity, polyphenol levels, and anthocyanin accumulation. Climatic data from the experimental period were also taken into account to understand the influence of the interaction between the vine and the rootstock.

The results indicate that the selection of the rootstock significantly affects both the quantity and quality of the production of grapes of the Feteasca neagra variety. Rootstocks with high vigor favor higher production, but can negatively influence the accumulation of phenolic compounds and uniform ripening of grapes.

On the other hand, rootstocks with moderate vigor ensure a balanced development of the plants, optimizing the synthesis of anthocyanins and polyphenols. Certain rootstocks have contributed to the increase of production, while maintaining a balanced ratio between sugars and acidity, essential for obtaining superior quality wines.

Other rootstocks influenced the phenolic composition, increasing the concentration of anthocyanins and polyphenols, compounds essential for the coloring intensity and stability of the wine.

Previous studies have shown that the interaction between the variety and rootstock can significantly influence the accumulation of sugars, the acidity level and, finally, the aromatic and taste profile of the wine.

Recently, research has focused on evaluating the long-term effects of different rootstocks on the adaptability of Fetească neagră to climate change, highlighting rootstocks that confer better resistance to drought and thermal fluctuations (Vasilescu et al., 2022). Also, the importance of selecting a suitable rootstock is amplified by the new European regulations aimed at the sustainability of viticulture practices, requiring greater efficiency in the management of water and soil resources (EU Regulation 2019/1009).

The statistical analysis confirmed significant differences between the studied combinations, highlighting the importance of rootstock selection according to winemaking objectives and regional climatic conditions. Also, recent studies show that rootstocks influence the content of aromatic precursors of grapes, having a direct impact on the organoleptic profile of the final wine (Ollat et al., 2016). The study suggests that rootstocks adapted to drought and high temperatures help stabilize grape production and maintain phenolic integrity, being preferred in the context of climate change.

In addition, the interaction of the rootstock with the grafted variety can also influence its behavior in terms of resistance to diseases and pests, as well as its ability to adapt to different types of soil. Recent studies suggest that certain rootstocks can reduce water stress by improving water absorption efficiency, playing an essential role in maintaining the plant's water balance (Keller, 2020).

The metabolic analysis of the grapes from the grafting combinations studied indicates that rootstocks can influence the biosynthesis of aromatic compounds, thus contributing to the definition of the sensory profile of the resulting wine. For example, it has been found that rootstocks with moderate vigor favor the accumulation of aromatic precursors, while more vigorous rootstocks can negatively influence the expression of fine aromatic characteristics of the wine (Santesteban et al., 2018).

This study provides valuable information for winegrowers and oenologists in the selection of the most suitable rootstocks for Fetească neagră, aiming to balance the efficiency of production with the maintenance of the superior quality of the grapes.

MATERIALS AND METHODS

The research was carried out in the ecopedoclimatic conditions of the Valea Călugărească wine center between 2020 and 2024 and the impact of climatic variables (average air temperature, precipitation, relative humidity and duration of sunshine) on grape production and its quality in the Fetească neagră variety grafted on a wide range of rootstocks with a very different genetic origin was analyzed. Rootstocks belonging to the species Vitis riparia (RG) as well as hybrids Berlandieri x Riparia (8B, 5BB, 2C, SO4-4, 125 AA, 57D, 26C, 71C), Berlandieri x Rupestis (140 Ru) and Vinifera x Berlandieri (41 B) were followed.

Within the experimental device, the grafting combinations related to the Fetească neagră variety were placed in the field in randomized blocks, with 5 replications, planting distance of 2.2 x 1.2 m (3787 vines/ha), and the training form is the bilateral cordon spurred on the semi-stem (h=60 cm).

The soil in the experimental polygon is reddish brown molic vertic, with a loam clay texture, weak acid pH (6.1), well supplied with humus (2.2%) and useful mineral elements (N, P, K).

Assessments were made on the grape harvest from a quantitative and qualitative point of view at the technological maturity, at the same stage for all the grafting combinations. The following analyses were performed: sugar content-determined by refractometry (OIV 2021a); total acidity- determined by titration with NaOH (OIV 2021b), The polyphenol content was determined by the Folin-Ciocalteu method (Ribéreau-Gayon et al., 2006), total and extractable anthocyanins were analyzed by spectrophotometry at 520 nm. Regarding the statistical analysis of the data, the means were compared using the ANOVA test to identify significant differences between rootstocks, principal component analysis (PCA) to highlight the relationships between variables, Pearson correlations to determine the associations between production, sugars, acidity and polyphenols, linear regressions to analyze the determinants of grape yield and quality, cluster analysis to group rootstocks according to their performance on Fetească neagră.

RESULTS AND DISCUSSIONS

The meteorological data recorded in the 2020-2024 period indicate a thermal regime characterized by average annual temperatures that oscillate between 11.8°C (2021) and 13.8°C (2024).
Compared with normal (1990-2019), the average temperature during the vegetation period increased by 0.4°C (2022), 0.8°C (2023), respectively 2.2°C (2024) (Figure 1).
The precipitations level was very low in the winter months, with 1.4 mm (2020) and 5.8 mm (2022) recorded in January compared with the multi-year average, 37.7 mm.

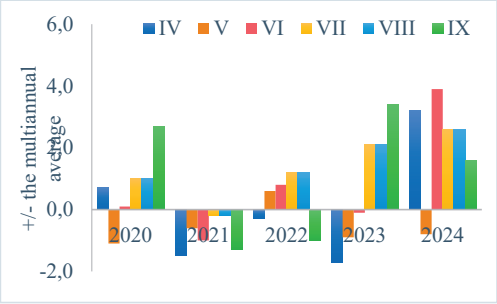

Figure 1. Monthly average temperature during the growing season of the years 2020-2024 compared to the multiannual average of 1990-2019

This became an excess in May when 84.5 mm was recorded compared with 71.6 mm, the multi-year average (Figure 2).

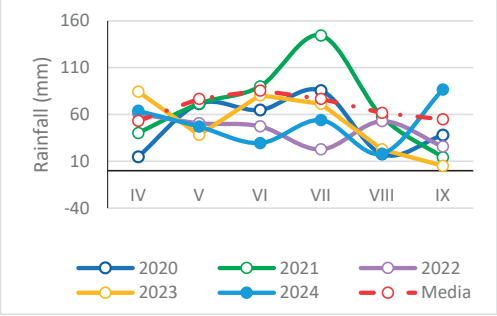

Figure 2. Monthly average rainfall during the growing season of the years 2019-2023 compared to the multiannual average of 1990-2019

The very high air temperatures and the low volume of rainfall in the summer months have made the phenomenon of grape wilting frequently manifest itself in the grape plantations during the veraison-ripening period.
Compared to the 1990-2019 average, the duration of sunshine increased by 21 hours (2021), 34 hours (2020), 47 hours (2022), 275 hours (2023), respectively 304 hours (2024), (Table 1).

Table 1. The duration of sunshine in the period 2020-2024, compared to the average for 1990-2019

Year	Sunshine duration hours
1990-2019	1608
2020	1642
2021	1629
2022	1655
2023	1883
2024	1912

The average amplitude of the production variation in the period 1990-2019 was 0.80 kg/stump, the average grape production showed a minimum in the case of rootstock 93 RG (1.28 kg/vine) and a maximum in the case of rootstock SO 4-4 (2.08 kg/vine), and in the period 2020-2024 the average grape production showed a minimum in the case of rootstock 125 AA (0.74 kg/vine) and a maximum in the case of rootstock SO 4-4 (0.96 kg/vine).
In the Fetească neagră variety, the influence of rootstocks on grape production was obvious. The rootstocks from the Berlandieri x Riparia group had a different behavior.
The SO 4-4 rootstock (0.96 kg/vine) clearly stood out from the other rootstocks, followed by 140 Ru (0.96 kg/vine), 71 C (0.86 kg/vine) and 2 C (0.82 kg/vine), and the 125 AA rootstock (0.74 kg/vine) induced the lowest level of production.
In terms of grape production (kg/vine), the SO4-4 and 140 Ru rootstocks are significantly different from the 125 AA and 2 C rootstocks, while the 2 C and RG rootstocks do not show significant differences (Table 2).
The concentration of the must in sugars, the main qualitative factor of the production, depended to a lesser extent on the rootstocks used in the grafting combinations, with values between 240.4 g/l (140 Ru) and 263 g/l (57 D and Kober 5 BB), (Table 3).

Table 2. The grape production (kg/vine) of the variety/rootstock combinations

Rootstock	Average 1990-2019	Average 2020-2024
125 AA	1.640	0.744
2 C	1.850	0.819
RG	1.280	0.816
71 C	1.940	0.855
SO4-4	2.080**	0.963**
Kober 5 BB	1.760	0.882
140 Ru	1.790**	0.960**
57 D	1.980	0.850
26 C	1.550	0.812

The results obtained highlight the fact that regardless of the climatic conditions during the experimentation period, all the rootstocks taken in the study induced to the vinifera varieties, a level of sugar concentration sufficient to obtain wines with controlled designation of origin.
Rootstock 57 D has the highest sugar content and is significantly different from 140 Ru and 125 AA, and rootstocks K 5 BB and SO4-4 are close in values and do not differ significantly from other rootstocks in the same category (Table 3).

Table 3. The sugar content (g/l) of the variety/rootstock combinations

Rootstock	Average 1990-2019	Average 2020-2024
125 AA	219	245.9
2 C	210	241.7
RG	222	241.7
71 C	221	243.8
SO4-4	222	241.7
Kober 5 BB	221	252.3**
140 Ru	209	240.4
57 D	212	262.9**
26 C	214	241.7

The 57 D, Kober 5 BB rootstocks are significantly different from the RG, 2 C, SO4-4 and 71 C rootstocks, which do not show significant differences (Table 4).
As in the case of the concentration of the must in sugars, the rootstock has a relatively small influence on the acidity of the must.
The average values regarding the acidity of the must varied between 4.1 g/l (57 D) and 4.0 g/l (Kober 5 BB, 140 Ru, 26 C).

The relatively small influence of rootstock on the acidity of the must in vinifera varieties was also highlighted by the researches carried out by: Oslobeanu (1966) and Stoian (1999).

Table 4. The total acidity (g/l tartric acid) of the variety/rootstock combinations

Rootstock	Average 1990-2019	Average 2020-2024
125 AA	5.7**	4.3**
2 C	5.7**	4.2**
RG	5.5	3.9
71 C	5.1	4.2**
SO4-4	6.0**	3.9
Kober 5 BB	5.0	4.0
140 Ru	4.5	4.0
57 D	3.9	4.1
26 C	5.0	4.0

The content in total anthocyanins ranged from 2202 mg/l (125 AA), 2100 mg/l (RG), 2049 mg/l (SO4-4), compared to 2C whose content in total anthocyanins was only 1154 mg/l. (Table 5).

Table 5. The phenolic maturity of the analyzed varieties in the period 2020-2024

Rootstock	Total anthocyanins	Extractible anthocyanins	Extractability
125 AA	2202	1571	71
2 C	1154	783	68
RG	2100	1698	81
71 C	1685	948	56
SO4-4	2049	1366	67
Kober 5 BB	1525	932	61
140 Ru	1725	1101	64
57 D	1756	1195	68
26 C	1762	1195	68

As far as the extractable anthocyanin content is concerned, the variations were between 1689 mg/l (RG), 1571 mg/l (125 AA), 1366 mg/l (SO4-4).
Rootstocks such as 2C, Kober 5 BB, 71 C showed extractable anthocyanin contents of 783 mg/l, 932 mg/l and 71 C, respectively.
Polyphenols influence the structure of wine and its ageing capacity.
The results show that the rootstocks RG, SO4-4 and 125 AA have the highest values of total

polyphenols, indicating a high tannic potential (Table 6).

Table 6. The total polyphenols and the seed maturity of the analyzed varieties in the period 2020-2024

Varieties of grape	Total polyphenols
125 AA	73
2 C	42
RG	99
71 C	49
SO4-4	92
Kober 5 BB	52
140 Ru	57
57 D	69
26 C	61

The significant differences confirm the variability of anthocyanin and polyphenol content between varieties, with less impact on extractability.

In order to better understand how rootstocks are grouped according to production, sugars, acidity and phenolic maturity and to reduce the data sizes and show which variables best explain the variation, principal component analysis was performed.

PC1 (64.2% of the variation) is influenced in Principal Component 1 (PC1) explains 64.2% of the total variation. It is strongly influenced by production and sugars.

Main Component 2 (PC2) explains 25.8% of the variation, being more sensitive to variations in acidity.

Depending on the results obtained, the rootstocks are grouped as follows:

- rootstocks such as 140 Ru and SO4-4 are positioned towards the right end of PC1, which indicates high production.
- 57D and K5BB are grouped towards the left side of PC1 and top on PC2, indicating a high sugar content and moderate acidity.
- the rootstocks in the center of the graph, such as the RG and 71C, provide a balance between production and quality.

This analysis confirms that the selection of the rootstock significantly influences the qualitative and phenolic parameters of Feteasca neagră grapes, and its optimal choice can improve the quality of the wine produced.

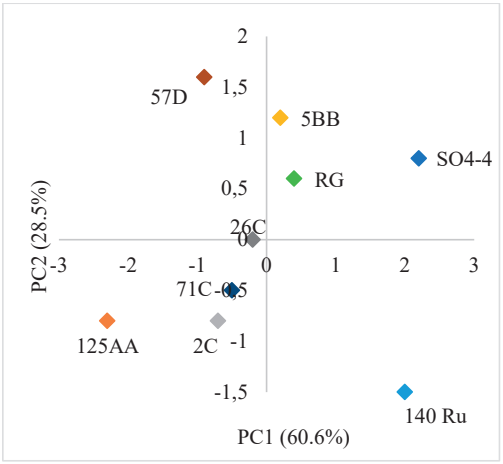

Figure 3. Principal component analyses

CONCLUSIONS

Because the p-value < 0.05, there are statistically significant differences between the analyzed rootstocks in terms of production. In other words, the rootstock significantly influences grape production. Because the p-value < 0.05, there are statistically significant differences between the analyzed rootstocks in terms of sugar content. Therefore, the rootstock significantly influences the sugar content of the grapes. In the case of acidity, the p-value > 0.05, so there are no statistically significant differences between the analyzed rootstocks. This means that the rootstock does not significantly influence the acidity of the grapes.

Clasificarea portaltoilor în funcție de obiective:

If you want to obtain a maximum production rootstock such as SO4-4 and 140 Ru.

If the quality of the production is desired, implicitly a high sugar content, respectively 57 D and K 5 BB quality wines.

If a balance between production and quality is desired rootstocks such as 71 C and RG are recommended.

As for the estimated profit, the most profitable rootstock is 57 D, although the production is not the highest, the high sugar content leads to a higher price per kg and, implicitly, to the highest profit.

The only balanced rootstock is K5BB, which ensures the best combination of production and sugars, generating solid profit.

To maximize production, but moderate profit, SO4-4 and 140 Ru rootstocks are recommended, which ensure high production, but lower sugars limit the price per kg, reducing profit compared to other rootstocks.

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