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PERFORMANCE OF SELECTED CLONAL ELITES FROM POPULATIONS OF THE CULTIVARS 'PERLETTE', 'PAULA', AND 'CENTENNIAL SEEDLESS' UNDER THE CONDITIONS OF THREE ROMANIAN VITICULTURAL AREAS

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Abstract

The study analyzes the performance of clonal elites of the cultivars 'Perlette', 'Paula', and 'Centennial Seedless', tested in three representative viticultural areas of Romania: population selections of the cultivar 'Perlette' in Murfatlar, those of 'Paula' in Iasi, and those of 'Centennial Seedless' in Stefanesti-Arges, over two viticultural years (2024-2025). Within this study, eighteen clonal elites were comparatively evaluated, assessing their performance relative to the control variant. The main climatic, phenological, agrobiological, productive, and technological indicators were analyzed in order to identify clonal elites with superior potential for expansion in cultivation. Significant differences among viticultural areas reflect the climatic impact on bud fertility, phenology, yield, and grape quality. During the study period, the clonal elites 'Perlette 7/2/5', 'Paula 5/1/4', and 'Centennial Seedless 5' demonstrated the best performance in terms of productivity and quality, ensuring average yields of 15-24 t/ha. These results recommend the varieties for testing, homologation, and expansion in the studied vineyards and in areas with similar conditions, while also enhancing the profitability of viticultural holdings through the high economic potential of table grapes.

Key words*: clonal selection, quality, productivity, stability, variability.*

INTRODUCTION

Vitis vinifera is one of the most important horticultural species worldwide, owing to its economic, nutritional, and social significance. In recent decades, the table grape sector has become increasingly important at a global level, driven by consumer demand for fresh, high-quality, seedless fruit with an attractive appearance and superior organoleptic characteristics (Keller, 2022; OIV, 2023). Concurrently, climate change, manifested through rising temperatures, irregular precipitation patterns, and a higher frequency of extreme weather events, has significantly affected grapevine productivity and fruit quality. Under these conditions, stability and adaptability have become key priorities in viticultural research (IPCC, 2023; van Leeuwen & Destrac-Irvine, 2017).

In Romania, grapevine cultivation has a long-standing tradition, supported by favorable pedoclimatic conditions across several viticultural regions. Table grape production is particularly well developed in areas such as Murfatlar (Dobrogea), Iași (Moldavia), and Ștefănești-Argeș (Muntenia), where thermal resources, solar radiation, and soil characteristics provide optimal conditions for obtaining high-quality fresh grapes (Teodorescu et al., 2021; Oșlobeanu et al., 1991; Cotea et al., 2006). The evolution of the table grape sector in Romania has been shaped by both traditional cultivars and the introduction of new seedless

varieties, which are increasingly preferred by consumers (Olteanu et al., 2015; Dejeu, 2010).
Seedless cultivars intended for fresh consumption are highly valued for their earliness, berry size, uniformity, and taste. However, their performance is strongly influenced by genotype-environment interactions, particularly under conditions of thermal and water stress (Keller, 2022). Previous studies (Reynolds & Wardle, 2001), as well as more recent research, have demonstrated that yield stability and fruit quality are closely linked to the adaptability of genotypes to specific environmental conditions. In Romanian viticulture, similar conclusions have been reported regarding the influence of ecological conditions on grape production and quality (Cotea et al., 2006; Oșlobeanu et al., 1991).
Clonal selection represents a fundamental approach for the improvement of grapevine cultivars, aiming to identify elite genotypes with superior productivity, consistent fruit quality, and enhanced adaptability to local environmental conditions (OIV, 2020). In such studies, the focus is placed on assessing the performance stability of individual genotypes across varying environmental conditions, rather than on direct comparisons between cultivars (Becker & Léon, 1988). Romanian research has also emphasized the importance of clonal selection in improving grapevine assortments and ensuring the biological and productive stability of cultivars (Teodorescu et al., 2021; Dejeu, 2010).
In Romania, clonal selection programs have made a significant contribution to the improvement of grapevine assortments, including both wine and table grape cultivars (Teodorescu et al., 2021). Within this context, the present study reports partial results of clonal selection in three seedless table grape cultivars 'Perlette', 'Paula', and 'Centennial Seedless', with the aim of identifying elite genotypes characterized by high productivity, superior fruit quality, and good adaptability to the environmental conditions of the study area.

MATERIALS AND METHODS

The research was conducted over two viticultural years (2024-2025) and involved the study of 18 clonal elites, analyzed in comparison with the control variant, belonging to table grape cultivars selected for their agronomic and commercial potential. The studied elites belong to the cultivars 'Perlette', 'Paula', and 'Centennial Seedless', located in distinct viticultural areas, namely the Murfatlar vineyard, the Iași vineyard, and the Ștefănești-Argeș vineyard. Five clonal elites were studied for the 'Perlette' variety: 16/5/11, 23/8/2, 14/7/2, 9/3/15, and 7/2/5. For the 'Paula' variety, five elites were also studied: 3/4/3, 7/6/3, 9/1/6, 4/2/1, and 5/1/4. For the 'Centennial Seedless' variety, eight elites were studied, numbered from 1 to 8.
The objective of the study was to evaluate the stability of these clonal elites originating from different cultivars by analyzing the consistency of their performance across three contrasting pedoclimatic environments.
The analysis of clonal elites originating from different cultivars requires a different methodological approach compared to intravarietal studies. In this case, the aim was not to perform absolute comparisons of yield or quality among clonal elites, but rather to evaluate the coherence of each elite's response to environmental variability.
The monitored parameters included vegetative and productive indices, phenological stages of vegetation, productivity, and quality of these clonal elites. Since the clones originate from different cultivars, the evaluation focused on the relative stability of their performance across different environments, rather than on direct comparisons of the absolute levels of yield or quality.
The analyzed parameters included meteorological data during the study period, the progression of phenological stages, the relative and absolute fertility coefficients, yield (kg/vine), as well as the analysis of fruit quality (sugar, g/L; acidity, g/L H_2SO_4), together with the determination of the gluco-acidimetric index.
The data were statistically processed using analysis of variance (ANOVA), and the significance of differences was evaluated using the Least Significant Difference (LSD) corresponding to Fisher's LSD test (Gomez & Gomez, 1984).
The Least Significant Difference was established using the common experimental error obtained from the analysis of variance (ANOVA), by applying the formula corresponding to Fisher's LSD test. The

significance of the differences between the clonal elites and the control (the original cultivar) was analyzed by calculating the Least Significant Difference (LSD) using Fisher's LSD test. The threshold values of the LSD were established according to the experimental variability and the chosen levels of statistical significance using the following formula:

$$DL = t_{\alpha,df} \cdot \sqrt{\frac{2 \cdot MSE}{r}}$$

where:

$t_{\alpha,df}$ represents the critical value from the Student's t distribution for the chosen significance level (5%, 1%, 0.1%) and the degrees of freedom of the error;

MSE represents the mean square error (experimental error) obtained from ANOVA;

r represents the number of replications, corresponding to the number of observation years.

RESULTS AND DISCUSSIONS

The data analysis presented in Tables 1 and 2, referring to the climatic conditions and the phenological evolution of the grapevine during the viticultural years 2024 and 2025, highlights significant differences among the three analyzed viticultural areas - Murfatlar, Iași, and Ștefănești-Argeș - differences that influenced the development of the vegetative cycle and grape ripening.

The annual mean temperature recorded the highest values in the Ștefănești-Argeș vineyard (15.5°C in 2024) and the lowest in the Iași vineyard (12.2°C in 2024). Comparatively, between the two years, a slight increase in mean temperature was observed in Murfatlar (14.5°C → 14.8°C) and Iași (12.2°C → 12.6°C), while in Ștefănești-Argeș a significant decrease was recorded (15.5°C → 13.6°C). These thermal variations were directly reflected in the dynamics of the vegetation phenophases.

Thus, for the cultivar 'Perlette' cultivated in Murfatlar, budburst occurred later in 2025 (18 April) than in 2024 (2 April), indicating a cooler spring and a slower accumulation of useful temperatures. A similar trend was observed for the cultivars 'Paula' (Iași) and 'Centennial Seedless' (Ștefănești-Argeș), where phenophases were shifted according to the temperature evolution during the early vegetation period.

The number of days with maximum temperatures above 30°C, an indicator of thermal stress on grapevine, was higher in 2024 than in 2025. In Murfatlar, 75 such days were recorded in 2024 compared with 61 in 2025, while in Ștefănești-Argeș there were 89 days compared with 64 days. The reduction in the frequency of extreme temperatures in 2025 contributed to delays in certain phenophases, particularly flowering and veraison, and was associated with a lower accumulation of effective temperatures.

The pluviometric regime showed important variations between the two years. In Murfatlar, annual precipitation decreased in 2025 (680.8 mm → 342 mm), while precipitation during the vegetation period decreased from 345.6 mm to 165.2 mm, leading to a pronounced reduction of the hydrothermal coefficient (1.2 → 0.5) and the establishment of significant water stress. In contrast, in the Iași and Ștefănești-Argeș vineyards, the pluviometric regime was more balanced, and the hydrothermal coefficient recorded values more favorable for vegetative development and sugar accumulation.

These climatic conditions influenced phenological evolution, particularly in Murfatlar, where for the cultivar 'Perlette' the veraison stage was delayed in 2025 (4 August) compared with 19 July in 2024, suggesting that water deficit slowed berry development.

The Oenoclimatic Aptitude Index (IAOe) and the Huglin Heliothermal Index recorded lower values in most areas in 2025, indicating less favorable conditions for optimal grape ripening. In Murfatlar, for example, the Huglin index decreased from 2,688.5 to 2,434.3, while IAOe decreased from 5,277.4 to 5,197.2.

This reduction explains the phenological shifts observed, particularly the delay in full ripening: the cultivar 'Perlette' reached maturity on 28 August in 2025 compared with 10 August in 2024.

No significant differences in phenology were observed between the studied clonal elites and the control cultivars; therefore, only the data corresponding to the control cultivars were interpreted. Overall, the results demonstrate that interannual climatic variability significantly influences grapevine phenology.

Table 1. Analysis of the climatic conditions during the 2024-2025 period in the three studied viticultural areas

Climatic elements analyzed	Area 1 - Murfatlar vineyard		Area 2 - Iasi vineyard		Area 3 - Stefanesti Arges vineyard	
	2024	2025	2024	2025	2024	2025
Mean annual temperature T,°C	14.5	14.8	12.2	12.6	15.5	13.6
Number of days with maximum temperatures >30°C	75	61	56	42	89	64
Σ Total annual precipitation, mm	680.8	342	509.1	657.4	490.6	572.4
Σ Total precipitation during the vegetation period, mm	345.6	165.2	400.2	313.8	275.8	349.4
Hydrothermal coefficient (CH)	1.2	0.5	1.09	0.97	0.8	1.1
Oenoclimatic aptitude index (IAOe)	5,277.4	5,197.2	5,027.5	4,689.9	3,419	3,217
Huglin heliothermal index (IH)	2,688.5	2,434.3	2,600.5	2,193.7	2,318	2,316.5
Night cooling index (IF)	14.2	12.9	14.1	12.4	11.9	11.9

Table 2. Progression of the vegetation phenophases of the three studied genotypes

Progression of the vegetation phenophases	'Perlette' Area 1 – Murfatlar		'Paula' Area 2 – Iași		'Centennial Seedless' Area 3 – Ștefănești Argeș	
	2024	2025	2024	2025	2024	2025
Budburst (BBCH 08-09)	02 Apr.	18 Apr.	05 Apr.	19 Apr.	18 Apr.	23 Apr.
Flowering (BBCH 65-68)	27 May	12 June	27 May	07 June	05 June	12 June
Veraison (BBCH 85)	19 July	04 Aug.	13 July	23 July	16 July	30 July
Full maturity (BBCH 89)	10 Aug.	28 Aug.	09 Aug.	02 Sept.	14 Aug.	25 Aug.

Analyzing the data presented in Table 3, for the cultivar 'Perlette' (Murfatlar), in the case of CFR, the clonal elites 9/3/15 and 7/2/5 stand out, with increases of +0.15, highly significant (), indicating a clearly superior relative fertility compared to the control and suggesting a better reproductive potential under the given conditions. The other variants do not differ statistically from the control, which reflects a relatively uniform expression of this parameter among the remaining elites.

For CFA, highly significant differences () are recorded for elite 7/2/5 (−0.20), indicating a notable decrease in absolute fertility compared with the control. At the same time, 16/5/11 shows a significant reduction (**), confirming a similar but less pronounced trend. The remaining elites are statistically non-significant, maintaining values close to the control and showing no meaningful deviations.

For the cultivar 'Paula' (Iași), CFR shows no significant differences, except for elite 5/1/4 (+0.10, **), which indicates a moderate but statistically supported increase compared with the control. The other variants remain statistically similar, suggesting limited variability for this trait within the cultivar.

For CFA, the elites 3/4/3 and 5/1/4 stand out (+0.15, **), indicating improved absolute fertility and a favorable performance. Additionally, elite 4/2/1 records a smaller but significant increase (+0.10, *), suggesting a positive but less pronounced effect. The rest of the variants do not show statistically significant differences and remain comparable with the control.

In the case of the cultivar 'Centennial Seedless' (Ștefănești-Argeș), only elite 5 records a highly significant increase in CFR (+0.20, ***), clearly distinguishing itself from the other variants and highlighting its superior relative fertility. The other elites do not differ significantly from the control, indicating stable values across genotypes.

For CFA, highly significant negative differences are observed for elites 1 (−0.25, ***) and 7 (−0.20, ***), indicating a considerable reduction in absolute fertility compared with the control. The other variants are statistically comparable with the control, maintaining similar values despite minor numerical differences.

Table 3. Comparative analysis of CFR and CFA in clonal elites of the studied cultivars across the three viticultural areas

Genotipe	Clonal elite	Relative Fertility coefficient (CFR)			Absolut Fertility coefficient (CFA)		
		Multianual mean	Differences (+-)	Significance	Multianual mean	Difference (+-)	Significance
'Perlette' Area 1-Murfatlar	16/5/11	0.50	−0.05	ns	1.05	−0.15	**
	23/8/2	0.50	−0.05	ns	1.25	+0.05	ns
	14/7/2	0.50	−0.05	ns	1.15	−0.05	ns
	9/3/15	0.70	+0.15	***	1.15	−0.05	ns
	7/2/5	0.70	+0.15	***	1.00	−0.20	***
	Control (initial cultivar)	0.55	-	-	1.20	–	–
'Paula' Area 2-Iași	3/4/3	0.75	+0.05	ns	1.25	+0.15	**
	7/6/3	0.75	+0.05	ns	1.10	0	ns
	9/1/6	0.65	−0.05	ns	1.15	+0.05	ns
	4/2/1	0.75	+0.05	ns	1.20	+0.10	*
	5/1/4	0.80	+0.10	**	1.25	+0.15	**
	Control (initial cultivar)	0.70	–	–	1.10	–	–
'Centennial Seedless' Area 3-Ștefănești Argeș	1	0.70	−0.05	ns	1.00	−0.25	***
	2	0.80	+0.05	ns	1.25	0	ns
	3	0.80	+0.05	ns	1.30	+0.05	ns
	4	0.70	−0.05	ns	1.20	−0.05	ns
	5	0.95	+0.20	***	1.30	+0.05	ns
	6	0.80	+0.05	ns	1.20	−0.05	ns
	7	0.70	−0.05	ns	1.05	−0.20	***
	8	0.80	+0.05	ns	1.30	+0.05	ns
	Control (initial cultivar)	0.75	–	–	1.25	–	–
		DL 5% CFR = 0.06				DL 5% CFA = 0.07	
		DL 1% CFR = 0.09				DL 1% CFA = 0.11	
		DL 0.1% CFR = 0.14				DL 0.1% CFA = 0.17	

ns – not significant; *, **, *** – significant for $p < 0.05$; $p < 0.01$; $p < 0.001$.

In the case of the cultivar 'Perlette' from Murfatlar, in 2024 all elites exceeded the control, with elite 7/2/5 standing out through the highest yield. In 2025, a general reduction in yield was observed; however, the elites maintained an advantage over the control, indicating a better capacity for adaptation under less favorable conditions.

For the cultivar 'Paula' from Iași, yield was relatively balanced in 2024, while in 2025 an increasing trend was observed for most elites. Elite 5/1/4 stands out for its consistency and superior performance in both years, suggesting good yield stability.

For the cultivar 'Centennial Seedless' from Ștefănești-Argeș, the year 2024 was characterized by moderate yields, whereas in 2025 a significant increase was recorded for all variants. Elite 5 is distinguished by superior productivity and high adaptability (Figure 1).

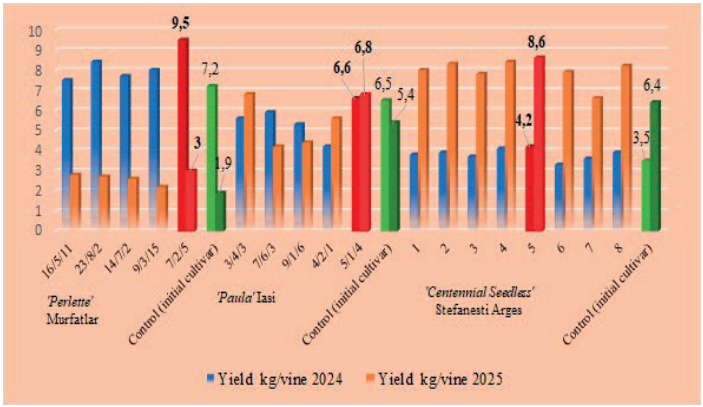

Figure 1. Evaluation of yield (kg/vine) of the elites compared with the control

According to the data presented in Table 4, in the case of the cultivar 'Perlette' (Murfatlar), in 2024 clear differences among the elites can be observed regarding sugar accumulation. Elite 7/2/5 (152 g/L) recorded a significant difference compared with the other elites and the control (116 g/L). In 2025, the sugar content decreased and became more uniform (110-114 g/L), indicating a restrictive climatic influence on ripening. In 2024, acidity was low (2.3-3.3 g/L), but in 2025 it increased significantly (5.2-5.4 g/L), exceeding the control in most cases. This evolution indicates slower ripening and reduced sugar accumulation in the second year.

Regarding the cultivar 'Paula' (Iași), a high level of sugars was observed in both years. In 2025, a significant increase was recorded for most elites (up to 220 g/L in 7/6/3), exceeding the control (209 g/L). Acidity remained relatively constant, with slight decreases in 2025 for some elites (for example, 7/6/3-3.6 g/L), indicating a favorable balance between sugars and acids and good adaptation to the conditions of the Iași viticultural area.

For the cultivar 'Centennial Seedless' (Ștefănești-Argeș), sugar values were high and relatively stable in both years (195-210 g/L). Elite 5 stands out with the highest sugar content in 2024 (210 g/L) and maintains a superior level in 2025 as well (206 g/L). Acidity slightly increased in 2025 compared with 2024, but remained within moderate limits (3.1-4.0 g/L). Compared with the control, most elites showed lower acidity in 2025, suggesting more advanced ripening.

Table 4. Crop quality during the study period

Cultivar/vineyard area	Clonal elite	Sugars g/L		Acidity H_2SO_4 g/L	
		2024	2025	2024	2025
'Perlette' / Murfatlar	16/5/11	124	113	2.7	5.2
	23/8/2	108	111	2.3	5.2
	14/7/2	112	110	2.4	5.3
	9/3/15	128	112	2.8	5.4
	7/2/5	152	114	3.3	5.3
	Control (initial cultivar)	116	110	2.5	5.8
'Paula' / Iași	3/4/3	180	191	4.4	4.4
	7/6/3	182	220	4.4	3.6
	9/1/6	182	207	4.4	4.5
	4/2/1	182	195	4.3	4.4
	5/1/4	186	217	4.2	4.2
	Control (initial cultivar)	186	209	4.2	4.1
'Centennial Seedless' / Ștefănești Argeș	1	199	196	3.1	3.9
	2	198	198	3.2	3.6
	3	198	195	3.1	4.0
	4	199	197	3.0	3.6
	5	210	206	2.6	3.1
	6	204	201	3.0	3.3
	7	203	202	3.2	3.1
	8	206	203	2.9	3.2
	Control (initial cultivar)	199	195	3.2	4.1

In the case of the cultivar 'Perlette' (Murfatlar), in 2024 the values of the gluco-acidimetric index were relatively uniform (45-47), comparable with the control (46), indicating an appropriate technological balance. In 2025, the index values decreased significantly (20-22), including the control (19), as a result of reduced sugar accumulation and increased acidity. However, the elites still maintained slightly higher values than the control, such as elite 7/2/5, suggesting relatively better adaptation under less favorable conditions.

Regarding the cultivar 'Paula' (Iași), in 2024 the values were similar (41-44), close to the control (43), indicating balanced ripening. In 2025, a marked increase in the gluco-acidimetric index was observed for most elites, particularly for 5/1/4 (52), exceeding the control. This evolution reflects superior sugar accumulation and/or a reduction in acidity, confirming good adaptation to the climatic conditions of that year.

Analyzing the cultivar 'Centennial Seedless' (Ștefănești-Argeș), the values of this index are the highest among the three cultivars. In 2024,

Elite 5 stands out with a very high index (80), well above the control (62), indicating superior quality potential. In 2025, the values decreased slightly but remained high (48-66), with most elites exceeding the control (47). Elite 5 maintained its superiority (66), followed by elites 7 and 8 (Figure 2).

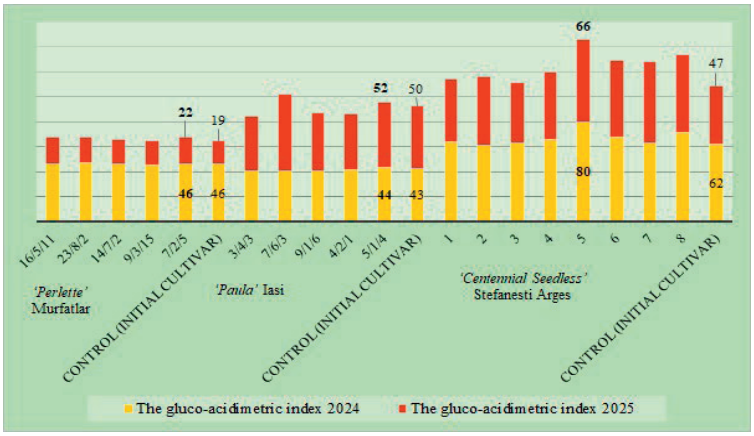

Figure 2. The gluco-acidimetric index

Figure 3 presents original photographs illustrating the clusters of the three initial cultivars studied in parallel with those of the superior elites.



a. 'Perlette' control b. 'Perlette elite 7/2/5' c. 'Paula' control d. 'Paula elite 5/1/4'



e. 'Centennial Seedless' control; f. 'Centennial Seedless elite 5'

Figure 3. Cluster characteristics of the initial cultivar – control – and the elite (a-b Area 1 - Murfatlar; c-d Area 2 - Iași, e-f Area 3 - Ștefănești Argeș)

CONCLUSIONS

Interannual climatic variability significantly influenced grapevine phenology and grape ripening in all three analyzed viticultural areas. The reduction in mean temperatures and heliothermal indices in 2025 led to phenological shifts and delayed ripening, particularly in the Murfatlar viticultural area.

Regarding the cultivar 'Perlette' (Murfatlar), elites 7/2/5 and 9/3/15 stood out through highly significant increases in the relative fertility coefficient (CFR), while elite 7/2/5 demonstrated relatively superior adaptation under restrictive conditions, maintaining quality values above the control even in the unfavorable year.

For the cultivar 'Paula' (Iași), elite 5/1/4 was distinguished by productive consistency and higher values of the gluco-acidimetric index in both years, confirming good stability and adaptation to the pedoclimatic conditions of the area. For the cultivar 'Centennial Seedless' (Ștefănești-Argeș), elite 5 stood out for high productivity and superior sugar content in both years, recording the highest values of the gluco-acidimetric index, indicating superior qualitative and commercial potential.

The differences between the elites and the control were, in most cases, more evident in productive and qualitative parameters than in phenological ones, suggesting that clonal variability mainly influences technological performance rather than the duration of the vegetative cycle.

The evaluation of relative stability demonstrated that certain elites ('Perlette 7/2/5', 'Paula 5/1/4', and 'Centennial Seedless 5') exhibit a superior capacity to adapt to pedoclimatic variations, recommending them for official registration and multiplication.

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