

Agrobiological evaluation of seedless grapevine cultivars for improving the grapevine assortment

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ABSTRACT

In the paper are presented the results of studying the agrobiological characteristics of some seedless cultivars from the Ampelographic collection of PI NIARAMV: 'Bessemeannyi V-6', 'Călina', 'Centennial seedless', 'Flame seedless', 'Kışmış lucistâi', 'Mecita', 'Otilia', 'Perlette', 'Perlon' – *V. vinifera* L. cultivars and interspecific cultivars 'Himrod', 'Interlaken' and 'Romulus'. The phenological stages, fertility coefficients, productivity indices and winter hardiness were assessed, and the relationships among the main fertility components were examined through linear regression analysis. The investigated cultivars exhibited a wide range of berry maturity periods—from very early to late—together with variable levels of fertility and productivity indices. Several genotypes showed favorable agronomic traits, highlighting their potential value as genetic resources for seedless grape breeding programs.

Keywords: phenophases, fertility, productivity indices, genotypes, *Vitis vinifera*

INTRODUCTION

Worldwide, grapes play a substantial role in food consumption, being one of the most widely used fruits (Iasiello, 2017). According to data provided by FAO and OIV (2016), grapes have the highest value of global production in the world. The use of fresh grapes and raisins in the last 20 years, on a global scale, has increased 1.5 times (Bucur, 2011). The market is in demand for grapes with an attractive external appearance, medium or large berries, of various colors, with an intact layer of bloom, with a crispy flesh consistency, aromatic taste and a low number of seeds. There is an increased demand for cultivars with seedless grapes and those grown with reduced chemical treatments, environmentally friendly. Dgani *et al.* (2014), mention that of the table grapes sold in the world, seedless cultivars account for about 80%, the lack of seeds being a much appreciated and sought-after quality. Seedless grapes have certain characteristics, which make the fruit of superior quality and are used both in fresh form and for technological processing to produce raisins, juices, compote, jam, marinades.

The trend for the consumption of seedless grapes has increased, and is continuously growing, thus, emphasis is placed on the creation and research of seedless cultivars, as well as the expansion of the cultivated areas of seedless cultivars. Due to the specific requirements of the classic seedless cultivars (of oriental origin) in relation to climatic conditions, their distribution area is limited. These cultivars are more widespread in regions with a longer vegetation period, with the high sum of temperatures and with warm and dry autumns. Cultivated in temperate climate areas, they are characterized by low productivity,

explained by the insufficiency of the necessary climatic conditions during the period of flower bud deposition (Constantinescu and Indreăş, 1976).

The need to complete the assortment with seedless cultivars requires the creation of cultivars with a short vegetation period, with an earlier flower bud deposition period, adapted to the climatic conditions of the temperate zone, with high genetic resistance to unfavourable biotic and abiotic environmental factors, high productivity, quality, precocity, large berry, obtaining ecological production, environmental protection, reduction of chemical pressure (Savin, 2012).

The success of breeding programs is determined by the presence and availability of a sufficient number of diverse, valuable genetic resources. The genotypes accumulated in the ampelographic collection of PI NIARAMV, including the seedless ones, represent a vast agrobiodiversity of genetic resources (Savin *et al.*, 2009; Savin, 2012; Tofan, 2023), which allows highlighting potential candidates for their inclusion in breeding programs, as parents, the creation of new seedless cultivars for the continuous improvement of the grapevine assortment in the Republic of Moldova.

MATERIALS AND METHODS

The research was conducted during 2018-2022 within the Ampelographic Collection and adjacent sectors of the Grapevine Gene Fund of the Scientific-Practical Institute of Horticulture and Food Technologies (currently Public Institution National Institute of Applied Research in Agriculture and Veterinary Medicine).

The Ampelographic collection and experimental fields are located in the southern part of the Chisinau municipality (46°58'39.65" N and 28°46'21.68" E, altitude 201 m), on plot with a south-westerly exposure, with a slope inclination of 3-5°. The soil is a weakly eroded ordinary chernozem, clayey, density 1.21-1.38 g/dm³, pH - 7.2-7.3. The study included introduced seedless cultivars (Table 1), diverse by direction of grape use, country of origin and genetic origin (intraspecific cultivars *V. vinifera* L., as well as interspecific cultivars 'Himrod', 'Interlaken' and 'Romulus').

Table 1. List of seedless cultivars included in the study

Cultivar	Country of origin	Genetic origin	Berry color
'Besemeannyi V-6'	Bulgaria	Italia x Kişmiş alb	Green yellow
'Călina'	Romania	Braghină x Sultanină	Rose
'Centennial seedless'	USA	Gold x [Emperor x Pirovano 75]	Green yellow
'Flame seedless'	USA	[Cardinal x Thompson seedless] x [(Red Malaga x Tifafihi Ahmer) x (Muscat de Alexandria x Sultanina)]	Dark red
'Himrod'	USA	Ontario x Kişmiş alb	Green yellow
'Interlaken'	USA	Ontario x Sultanina	Green yellow
'Kismis lucistâi'	R. Moldova	Cardinal x Kişmiş roz	Rose
'Mecita'	Ukraine	Ceauş roz x Kişmiş negru	Rose
'Otilia'	Romania	Alphonse Lavallee x Perlette	Blue black
'Perlette'	USA	Regina viilor x Kişmiş alb	Green yellow
'Perlon'	Argentina	Emperor x Perlette	Dark red violet
'Romulus'	USA	Ontario x Sultanină	Green yellow

Development of the main phenological phases during the vegetation period, Fertility (Fertile shoots and Coefficient of fertility), and the Index of productivity of seedless cultivars were made. Each genotype is represented by 5-10 plants. Planting scheme of 3.00 x 1.50 m, the training system of the bushes is a bilateral cordon on the trunk of 60 cm. The vine culture is

unprotected for winter conditions. Statistical processing of the data (regression analysis, ANOVA and LSD test) and graphical presentation of the results were carried out with the EXCEL and STATISTICA 7.0 program packages.

RESULTS AND DISCUSSIONS

The climate of the Republic of Moldova is temperate-continental and is characterized by relatively warm, short winters with little snow, warm and long summers, a sum of active temperatures of 2750- 2750-3400°C. The weather conditions of the experimental sectors correspond to the conditions of the Codru wine-growing area of the Republic of Moldova and represent the average values for the republic (Savin, 2012).

During the study period, various temperature regimes were observed, including dry summers with record high temperatures, which allowed the study of the behaviour of genotypes in extreme conditions. The average annual air temperature recorded values of +10.6°C ...+12.7°C, the absolute maximum reaching +33.2°C ...+35.4°C °C, and the absolute minimum -6.9°C ...-16.7°C (Figure 1, a). The amount of annual precipitation falling in the research years (2018-2022) varied between 403-666 mm, and in the vegetation period (April-October) it amounted to 260-465 mm (Figure 1, b). The year 2019 was recorded as the driest year in the research period.

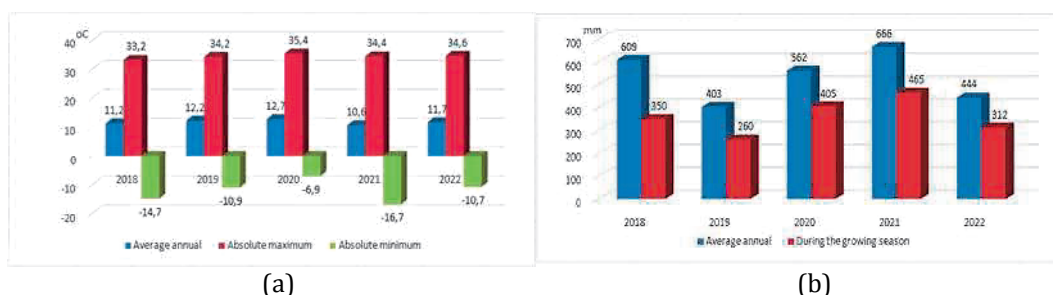


Figure 1. Average annual air temperature, absolute maximum and minimum (a) and amount of atmospheric precipitation (b) (2018-2022)

The length of the vegetation period and the progression of phenological phases depend on the interaction between the hereditary characteristics of the cultivar and the environmental conditions, which may vary from year to year (Perstnirov *et al.*, 2000).

Grapevine bud burst generally occurs in late April to early May, lasting from 3-5 days up to 10-15 days, and the interval between cultivars may reach two weeks. During the study period, bud burst in the analyzed cultivars was recorded between April 20 and May 07 (Table 2). The earliest bud burst was observed in the cultivars 'Interlaken', 'Himrod', and 'Mecita' while 'Perlon', 'Centennial seedless', 'Bessemeannyi V-6' and 'Călina' showed a distinctly later onset.

Blooming in the seedless cultivars occurred from late May to early June.

In 2021, the prolonged period of moderate temperatures slowed down the progression of the blooming stage, resulting in a delay of approximately two weeks (June 10-25) compared with the multiannual average. Based on the onset of blooming, early-flowering cultivars included 'Himrod' and 'Interlaken', medium-flowering cultivars included 'Flame Seedless', 'Perlette', 'Kişmiş Lucistâi', 'Romulus', and 'Centennial Seedless', whereas 'Călina', 'Perlon', and 'Bessemeannyi V-6' were classified as late-flowering.

Table 2. Development of the main phenological phases of the seedless cultivars (average for 2018-2022)

Cultivar	bud burst	blooming	beginning of berry ripening	full maturity of the berry	leaf fall
'Centennial' seedless	24.04-07.05	27.05-10.06	23.07-03.08	25.08-07.09	24.10-29.10
'Flame' seedless	21.04-05.05	27.05-11.06	22.07-30.07	23.08-05.09	26.10-01.11
'Perlette'	24.04-02.05	27.05-11.06	20.07-28.07	22.08-10.09	27.10-02.11
'Perlon'	24.04-03.05	30.05-14.06	28.07-05.08	30.08-14.09	23.10-31.10
'Călina'	23.04-07.05	28.05-12.06	28.07-07.08	03.09-15.09	23.10-01.11
'Otilia'	23.04-02.05	30.05-14.06	16.07-27.07	15.08-06.09	24.10-04.11
'Mecita'	20.04-04.05	27.05-10.06	25.07-05.08	03.09-20.09	24.10-04.11
'Bessemeannyi V-6'	24.04-04.05	01.06-12.06	12.08-22.08	18.09-26.09	24.10-04.11
'Himrod'	20.04-01.05	25.05-07.06	10.07-18.07	08.08-20.08	22.10-29.10
'Interlaken'	21.04-01.05	26.05-08.06	12.07-20.07	13.08-22.08	23.10-28.10
'Romulus'	22.04-03.05	28.05.-12.06	26.07-07.08	02.09-20.09	22.10-29.10

Based on the observational data (Figure 2), the duration of the period from bud burst to blooming in the studied seedless cultivars ranged from 39 days ('Centennial Seedless') to 45 days ('Perlon'). The average length of the ripening-maturity interval varied between 29 days in 'Himrod' and 43 days in 'Romulus'.

During the study years, the period of full maturity occurred between the second decade of August and the second decade of October (Table 2). The earliest ripening cultivars were 'Himrod' and 'Interlaken' (August 14–17 days), followed 15–17 days later by 'Perlette', 'Flame Seedless', 'Otilia' and 'Centennial Seedless'. The latest grape maturity was recorded in the cultivar 'Bessemeannyi V-6' (September 20–25).

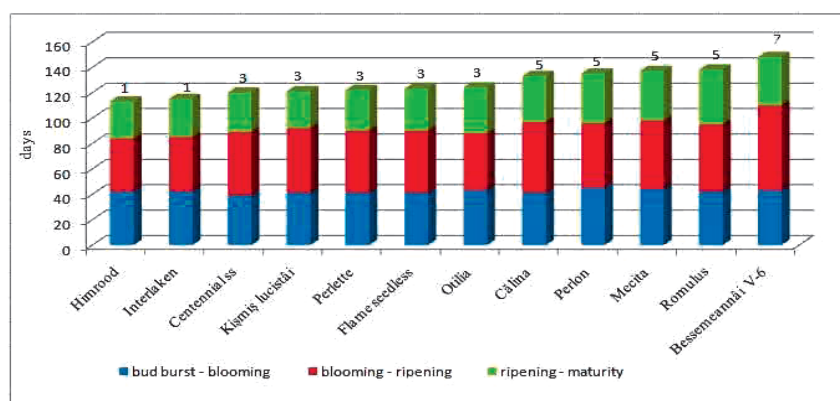


Figure 2. Duration of phenological phases of seedless genotypes

According to the number of days from bud burst to full maturity, the seedless cultivars were classified, following Buletinul I.C.V.V. (1988) and OIV (2001), by time of full maturity of berry as follows: Extra early (1): 'Himrod', 'Interlaken'; Early (2): 'Perlette', 'Flame seedless', 'Otilia', 'Centennial seedless', 'Kişmiş lucistâi'; Medium (5): 'Perlon', 'Călina', 'Mecita', 'Romulus'; Late (7): 'Bessemeannyi V-6'.

Seedless cultivars of the *Vitis vinifera* generally show lowest resistance, tolerating temperatures down to -15°C (Doulati, 2017). The percentage of buds that resumed growth

after pruning reflects their ability to withstand winter conditions (Guzun et al., 1976). Across the research years, this percentage ranged between 60.4% ('Flame seedless') and 73.6% ('Himrod') (Figure 3). Higher percentage of buds started in growth were recorded in 'Himrod', 'Perlon', and 'Perlette' while 'Flame seedless', 'Otilia', and 'Centennial seedless' differed significantly ($LSD_{0.95}=8.56\%$), by showing lower values.

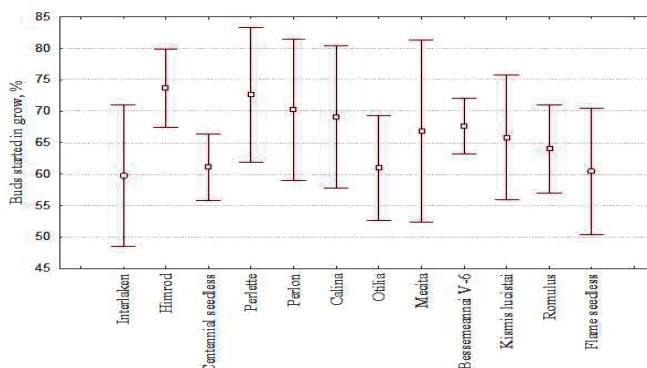


Figure 3. Percentage of buds started in growth
(* mean value, I-95% confidence interval)

Table 3. Fertility and productivity of the seedless cultivars (average for 2018-2022)

Cultivar	Fertile shoots, %	Coefficient of fertility		Index of productivity	
		absolute	relative	absolute	relative
'Centennial seedless'	50,2±1,8	1,1±0,2	0,6±0,2	544,5±4,0	271,0±3,7
'Flame seedless'	50,7±0,9	1,2±0,2	0,6±0,1	263,1±3,8	127,9±3,1
'Perlette'	44,0±1,2	1,06±0,1	0,5±0,1	323,4±5,2	149,5±3,7
'Perlon'	44,6±1,6	1,05±0,1	0,48±0,2	459,4±3,0	194,2±4,1
'Călina'	48,0±1,8	1,2±0,2	0,6±0,2	343,8±3,2	164,9±2,5
'Otilia'	72,6±1,2	1,68±0,2	1,2±0,2	432,8±3,0	302,2±3,5
'Mecita'	50,3±1,3	1,2±0,2	0,6±0,2	411,7±5,7	207,4±4,1
'Bessemeannyi V-6'	47,1±0,9	1,15±0,1	0,52±0,1	477,6±5,2	215,9±3,1
'Kismis lucistai'	43,3±1,1	1,13±0,2	0,5±0,2	368,6±2,3	163,9±3,2
'Himrod'	59,1±1,9	1,16±0,1	0,7±0,02	228,7±2,2	144,7±3,3
'Interlaken'	66,5±1,5	1,26±0,02	0,75±0,2	200,7±3,8	118,5±2,7
'Romulus'	68,3±1,1	1,25±0,1	0,8±0,1	294,2±3,4	189,6±3,3
<i>LSD_{0,95}</i>	12,347	0,153	0,186	98,169	72,208

The percentage of buds that resumed growth showed medium to high values for all studied seedless cultivars. Since the data represent average values over several years, the observed differences reflect mainly the effect of the cultivar, with a smaller contribution of annual climatic variation. The basic characteristics of grape production are fertility and productivity, which largely determine both the quantity and the quality of the yield. Fertility is an important factor for assessing crop profitability. The percentage of fertile shoots is one of the key indices used to evaluate fertility and, according to Mustea (2004), typically ranges from 20–40% in seedless cultivars and 40–60% in table grape cultivars.

The cultivars 'Otilia' and the interspecific hybrids 'Romulus', 'Interlaken' and 'Himrod' recorded the highest average percentages of fertile shoots over the period 2018–2022

(Table 3). Lower values of this indicator were found in 'Perlette' (44.0%) and 'Perlon' (44.6%). These differences are mainly attributed to the genetic potential of the cultivars, while the influence of environmental conditions appears to be secondary.

The percentage of fertile shoots is influenced primarily by the hereditary potential of the genotype, and to a lesser extent by climate, soil, and cultivation practices. The absolute and relative fertility coefficients (CFA and CFR) are indicators that vary mainly with cultivar. Analysis of the average CFA and CFR values for the whole study period (Table 3) shows that the highest values were recorded for the cultivar 'Otilia' (CFA $\approx$ 1.7; CFR $\approx$ 1.2), followed by the interspecific cultivars 'Interlaken', 'Romulus' and 'Himrod', which generally exceeded the *V. vinifera* seedless cultivars in fertility.

Productivity represents the vine's ability to form and develop grape clusters and is closely correlated with fertility (Mustea, 2004). It was assessed by the absolute and relative productivity index, which expresses the average grape yield per shoot. For the entire research period, the highest average productivity indices (IPA and IPR) were recorded in 'Centennial Seedless', 'Bessemeannyi V-6', 'Otilia' and 'Mecita', while the interspecific cultivar 'Interlaken' showed lower average values compared with the other studied genotypes.

The productivity indices of the seedless cultivars varied from year to year. This variation can be explained by unfavourable environmental conditions during the formation and development of fertile buds in some years, which reduced the expression of the productive potential of the cultivars. According to productivity indices and following the criteria of Buletinul I.C.V.V. (1988), the studied genotypes were classified as follows: cultivars with high productivity indices – 'Bessemeannyi V-6', 'Perlon', 'Otilia'; and cultivars with medium productivity indices – 'Centennial Seedless', 'Flame Seedles', 'Perlette', 'Călina', 'Mecita', 'Romulus', 'Himrod' and 'Interlaken'.

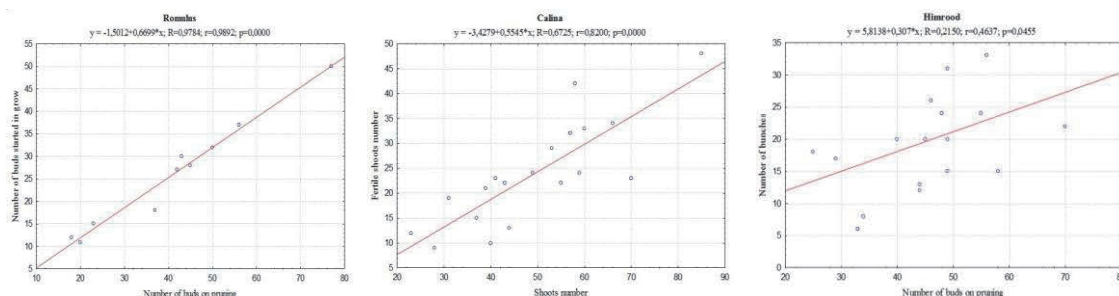
The cultivation of seedless cultivars, which are relatively new in the viticultural sector of the republic, requires an assessment of the relationships between fertility-related traits of the genotypes proposed for planting (Savin, 2012; Tofan, 2023). The fertility elements determined for the cultivars included in the study provide a basis for estimating the relationships among these traits before setting up specific agrotechnical experiments and help to orient further research. In order to highlight, for the studied seedless genotypes, the relationship between the total number of buds left after pruning and the number of buds that resumed growth, linear correlation coefficients were calculated and regression equations were constructed.

The relationship between the total number of buds pruning (x) and the number of buds started in vegetation (y), varies considerably among the studied seedless cultivars (Table 4). Most cultivars show relatively high linear correlation coefficient ($r=0.83-0.99$), indicating a consistent association between initial bud load and the number of buds that entered vegetation. Lower r values were recorded for 'Interlaken' ($r=0.78$), while 'Centennial Seedless' showed only a modest association ($r=0.45$) (Table 4, Figure 4).

The correlation between total shoots and fertile shoots shows notable variation between cultivars. Higher r values ($0.67-0.80$) were obtained for 'Centennial Seedless', 'Bessemeannyi V-6', 'Kişmiş lucistâi', and 'Romulus' genotypes. Several cultivars, including 'Mecita', 'Otilia', 'Călina', and 'Interlaken', exhibited even higher coefficients ($0.81-0.94$), suggesting a more consistent association between shoot development and fertile shoot formation. In contrast, 'Perlon' and 'Perlette' displayed moderate r values ($0.45-0.52$), while 'Flame Seedless' showed a weak association ($r=0.38$).

Table 4. Correlation of fertility elements for seedless cultivars

Cultivar	The regression equation and the linear correlation coefficient between:		
	no. total buds x no. buds started	no. total shoots x no. shoots fertile	no. buds started x no. of bunches
'Centennial seedless'	$y=11,88+0,27x$; $r=0,45$	$y=2,31+58x$; $r=0,80$	$y=3,44+0,22x$; $r=0,40$
'Flame seedless'	$y=1,47+0,59x$; $r=0,89$	$y=8,34+0,22x$; $r=0,38$	$y=16,89+0,005x$; $r=0,08$
'Perlette'	$y=2,77+0,68x$; $r=0,93$	$y=4,27+0,23x$; $r=0,45$	$y=5,92+0,156x$; $r=0,37$
'Perlon'	$y=3,24+0,62x$; $r=0,99$	$y=3,77+0,26x$; $r=0,52$	$y=7,07+0,07x$; $r=0,16$
'Călina'	$y=3,35+0,65x$; $r=0,95$	$y=-3,43+0,55x$; $r=0,82$	$y=0,21+0,42x$; $r=0,67$
'Otilia'	$y=4,42+0,53x$; $r=0,96$	$y=0,93+0,69x$; $r=0,93$	$y=7,77+0,38x$; $r=0,68$
'Mecita'	$y=4,52+0,58x$; $r=0,94$	$y=-7,63+0,71x$; $r=0,94$	$y=-7,98+0,55x$; $r=0,95$
'Bessemeannyi V-6'	$y=18,49+0,47x$; $r=0,83$	$y=-11,04+0,59x$; $r=0,67$	$y=-8,81+0,40x$; $r=0,63$
'Kismis lucistâi'	$y=27,22+0,005x$; $r=0,12$	$y=8,16+0,10x$; $r=0,57$	$y=14,99+0,07x$; $r=0,39$
'Himrod'	$y=1,76+0,70x$; $r=0,87$	$y=5,16+0,36x$; $r=0,52$	$y=5,79+0,31x$; $r=0,46$
'Interlaken'	$y=2,89+0,49x$; $r=0,78$	$y=5,47+0,94x$; $r=0,81$	$y=8,55+0,24x$; $r=0,22$
'Romulus'	$y=-1,50+0,67x$; $r=0,99$	$y=4,62+0,39x$; $r=0,79$	$y=4,62+0,36x$; $r=0,79$

**Figure 4.** Linear regression equation between the main fertility elements for seedless cultivars

The relationship between the number of buds that resumed growth and the number of clusters formed ranged from low to relatively high, depending on cultivar. Most genotypes showed r values between 0.63 and 0.79, with the highest value recorded for 'Mecita' ($r=0.95$), indicating a more proportional relationship between vegetative bud development and cluster formation. Moderate associations were found in 'Centennial Seedless', 'Perlette', and 'Himrod', while 'Flame Seedless', 'Perlon', and 'Interlaken' recorded low r values, indicating greater variability in cluster formation.

CONCLUSIONS

The studied seedless cultivars showed considerable diversity in the timing of full berry maturity, ranging from extra-early ('Himrod', 'Interlaken'), to early ('Otilia', 'Centennial Seedless'), medium ('Mecita', 'Călina') and late ('Bessemeannyi V-6'). This wide maturity span allows for an extended period of fresh grape consumption, from early August to late October, and provides valuable genetic material for breeding new seedless cultivars with targeted ripening periods.

The cultivars 'Otilia', 'Romulus', 'Himrod', and 'Interlaken' displayed higher values of shoot fertility, while 'Otilia', 'Bessemeannyi V-6' and 'Centennial Seedless' also expressed elevated productivity indices. These results indicate the capacity of these genotypes to ensure a

stable grape production potential and highlight their suitability as genetic sources for fertility and productivity in breeding programs.

The linear relationships observed between the total number of buds left after pruning and the number of buds that resumed growth ($r=0.68-0.98$), as well as between the total number of shoots and the number of fertile shoots ($r=0.60-0.97$), indicate consistent associations among vegetative and reproductive traits in several cultivars. These descriptive correlations underline the inherent vegetative and fertility potential of many of the studied genotypes.

ACKNOWLEDGEMENTS

The research was conducted within the framework of the project "State Program" 20.80009.5107.17 "Creation, evaluation and implementation of new grapevine cultivars and clones of homologated cultivars in accordance with climate change and the principles of sustainable agriculture".

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