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AGROBIOLOGICAL AND TECHNOLOGICAL CHARACTERISTICS OF TABLE GRAPES VARIETIES, GROWN IN THE TEMPERATE-CONTINENTAL CLIMATE FROM SOUTHWESTERN ROMANIA

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Abstract

Ensuring a diverse range of grape varieties for fresh consumption, for as long as possible during a year, represents an equally important goal not only for producers but for traders as well. Our paper presents results regarding the evaluation of seven table grape varieties, six seeded varieties: 'Cardinal', 'Victoria', 'Muscat Hamburg', 'Alphonse Lavallée', 'Matilde', 'Black Magic' and one seedless variety, 'Attica', in specific pedo-climatic conditions from South-Western Romania. Observations, measurements and analyses were focused on: agrobiological, quantitative and qualitative characteristics (weight, length and width of bunch; berry weight, their length and width; grape yield, sugar content, titrable acidity, °Brix/acidity ratio). The assessment of vulnerability of table grape varieties at winter temperature conditions were also analysed. In the conditions of a low supply and high demand for table grapes at the end of July -middle of August in our country, the good productions and early harvesting of the 'Victoria', 'Black Magic' seeded varieties and 'Attica' seedless variety, represents a high market opportunity for Romanian table grape producers.

Key words*: ampelographic features, grape market, grapevine, seedless.*

INTRODUCTION

Grapes for fresh consumption are fruits appreciated by consumers all over the world for their sensory, nutritional attributes (Agulheiro-Santos et al., 2022 ; Premachandran A. et al., 2019 ; Soural et al., 2019), as well as their protective role against liver, cardiovascular diseases, etc. (Liang et al., 2016).

With a worldwide production of approx. 30.11 million tons (OIV, 2021a), a total volume of approx. 3.7 million tons of exports and 3.4 million tons of imports, table grapes are the most demanded fruit worldwide, after apples, oranges and tangerines/mandarines (USDA, https://apps.fas.usda.gov/psdonline/app/index .html#/app/home/statsByCountry). The EU is the fifth world producer (5.8% of world production), China still being the largest producer (45.96%), followed by India and Turkey (USDA, 2022).

When purchasing table grapes, consumers show the importance of the various attributes that grapes must have. Medium bunch size grapes (400-500 g), with large berries, with sweet-sour juicy and crunchy flesh, seeded or seedless (Costescu A., 2013) are preferred. The Spanish consumers gave the greatest importance to taste, sweetness, thin skin and the absence of seeds (Piva et al., 2006), while the Chinese consumers prefer the intense red to dark purple colour of the skin and the muscat flavour (Zhou et al., 2015). On the other hand, when promoting new varieties from the international or national assortment, table grape producers put their focus on making them competitive from the point of view of: availability on the market (extra-early and early varieties), increased yield, commercial characteristics and resistance to diseases, pests or unfavourable environmental factors.

The textural changes of grape berries during transport or storage are also important characteristics in quality assessment and marketability of table grapes (Ejsmentewicz et al., 2015; Stroe et al., 2022).

The cultivar, climate (Chedea et al., 2021) and the cultivation practices have a decisive role in ensuring sustainable and quality grape production. Among the cultural practices they are mentioned: conventional or greenhouse cultivation (Pisciotta A. et al, 2022); pruning and training system (Costea et al., 2017; Măracineanu et al., 2022); soil and water

management (Permanhani et al., 2016), desease and pest control (Maia et al., 2014); the use of chemical compounds and plant hormones (Koyama et al., 2019; Shahab et al., 2020) etc.

The areas cultivated with table grape varieties have recorded a continuous decline in the last three decades in Romania (Cichi et al., 2019). In 2021, the total area under production with table grapes represents only 3.8% of the total vine-growing area under production in Romania. Consequently, the production is also reduced, approx. 52 thousand tons (Romanian NSI), far below the requirements of consumers in our country (7.9 kg/capita), which makes imports in 2021 to represent approx. 53 thousand tons (https://www.oiv.int/what-we-do/data-discovery-report?oiv). Although Romania has valuable varieties (Bucur & Dejeu, 2018; Cichi et al., 2012; 2017; Stroe, 2016; 2021; Rotaru et al., 2010), the largest share in the culture is held by the varieties: 'Chasselas doré' (40%) , 'Afuz Ali' (25%) and 'Muscat Hamburg' (approx. 12%). The need to renew the range of table grapes according to consumer requirements and the extension of the harvest period, are therefore, important conditions for increasing competitiveness on the market for Romanian table grape producers. For this purpose, in the last period, various varieties from the international range were introduced in the south of Romania and some varieties were reconsidered by the producers, such as: 'Cardinal', 'Victoria', 'Alphonse Lavallée' and others. In this context, the aim of this study was to evaluate some agrobiological, productive and qualitative characteristics of seven varieties of table grapes in the specific conditions of the south-west of Romania. Among these, there are 'Black Magic', 'Matilde' and the 'Attica' seedless variety which, to our knowledge, has not been studied in our country until now.

MATERIALS AND METHODS

Location and climatic characteristics. The study was conducted for three consecutive years (2019-2021) in a table grape commercial vineyard, located in Plenita-Orodel (Plaiurile Drancei vineyard, Dolj County), in the south-west part of Romania. From a geographical point of view, the studied vineyard area is located between the parallels of 44°13'00" north latitude and 23°23'00" east longitude (cca.180 m elevation). The main climatic characteristics during the study period are shown in Table 1. The weather data were obtained from the Craiova meteorological station (44°13' latitude and 23°52' longitude, 192 m altitude, Dolj County). In terms of helio-thermal resources, the studied years were favourable for the table grapes growing (IH5) but, there is still a semi-arid aspect during the year and growing season, based on De Martonne Aridity Index (Table 1).

Plant material. Six seeded table grape varieties: 'Cardinal', 'Victoria', 'Muscat Hamburg', 'Alphonse Lavallée', 'Matilde', 'Black Magic' and one seedless variety, 'Attica' were used (Table 2). The study was conducted on 8-10 years old vines. The randomized experimental design was used. Ten vines per variety were selected for the study, in three replications. The vines were cultivated under the same growing conditions, using rootstock Berlandieri x Riparia SO_4, with the 2.5 x 1.0 m spaces, semi-tall shape of the stem (with a trunk of 0.8 m), Double Guyot pruned, 25 buds/vine (8-10 buds/cane and 2 buds/spur), without irrigation. The viticultural management (fertilizer application, pest, diseases and weed control, etc.) was applied for all varieties in the same way.

Agrobiological, quantitative and qualitative characteristics. The ampelographic parameters were defined and recorded in accordance with OIV standardized descriptors and methods (OIV, 2009a; OIV, 2021b; UPOV, 2008). Percentage of fertile shoots, absolute and relative fertility index (A.f.i., R.f.i.) were established and calculated according to Cichi et al., 2022.

Sampling measurement and analyses. 20 bunches for each variety, 35 berries from the middle part of bunches, in 3 replicates, were used for measurements and analyses of bunch and berry traits, at full maturity. The berry diameter was determined with a digital caliper and the mass of bunches and berries with an analytical balance. SSC (°Brix) was measured using Kruss Optronic Hand Refractometer Hrot 32. The TA was determined by the titration method, NaOH 0,1N until pH 7.0 and expressed in gL^{-1} tartaric acid. The SSC and TA were done in three replicates. The maturity index was calculated as ratio SSC/TA, for each sample.

Table 1. Main climatic indexes of the experimental site

Climatic Index	Average 2019-2021	Class
SAT (Sum of average daily temperature > 10°C, April 1st to September 30th)	3853	
Winkler Index	1921	Temperate
Huglin`s heliothermal index (IH)	2503	IH5-Warm
Annual Rainfall (mm)	515	Normal for region
Rainfall in the growing season (mm, April 1st to September 30th)	305	Normal for region
De Martonne Aridity Index (I_{DM}, year)	17.43	Semi-arid
De Martonne Aridity Index growing season (I_{DM}, April 1st to September 30th)	10.32	Semi-arid

Table 2. List of varieties included in the study

Variety	Variety number VIVC	Pedigree confirmed by molecular markers Prime name Parent 1 x Parent 2	Country of origin of the variety	Skin Berry color*
'Cardinal'	2091	Alphonse Lavalée x Reines des vignes	USA	Rg
'Victoria'	13031	Cardinal x Afuz Ali	Romania	B
'Muscat Hamburg'	8226	Schiava grossa x Muscat of Alexandria	UK	N
'Alphonse Lavalée'	349	Dodrelyabi x Muscat Hamburg	France	N
'Black Magic'	7569	Moldova x Marshalskii	Republic of Moldova	N
'Matilde'	7512	Italia x Cardinal	Italy	B
'Attica'	17309	Alphonse Lavalée x Black Monukka	Greece	N

*B-blanc; N-black; Rg- red. (Source: VIVC, https://www.vivc.de/)

Statistical analysis. Each variable was examined by analysis of variance (One-way ANOVA). The morphometric, biochemical and productive characteristics are presented as means and standard deviation of each variable. All variables that were significant in the F test were analysed by HSD Tukey's test to mean separation and to establish if there were significant difference.

RESULTS AND DISCUSSIONS

Cold resistance. The resistance of table grape varieties to the critical conditions of negative temperatures during the winter is a valuable traits (Lisek, J., 2014; Vujović et al., 2017), especially in temperate climates, where such temperatures periodically occur (Bucur & Dejeu, 2020; Rotaru et al., 2010). The resistance of the vine to frost is influenced by various factors, among which: the variety, the climatic conditions during the vegetation period, the cultivation practices, the cold acclimation, intensity of frost etc. which have an important role. In the experimental conditions, where the absolute minimum temperature (TNn) was -11.8°C, the percentage of viability of the buds was over 70% in all varieties, with no statistically significant differences between the varieties (Table 3).

Fertility. The grapevine fertility is a characteristic of each variety, but it can also be influenced by other factors, including: rootstock, climatic conditions during inflorescences differentiation in year n-1 and cultivation practices (Rives M., 2000). The shoot fertility in some cultivars and in certain viticultural areas may be the main productivity factor (Antcliff & Webster, 1955). On the other hand, fertility and its distribution along the length of the cane, condition the decisions regarding the pruning system for each variety (Olteanu et al., 2002). The 'Victoria' and 'Black Magic' varieties have the highest percentage of fertile shoots and A.f.i. (Table 3). The significant differences regarding the percentage of fertile shoots are also observed between 'Black Magic' compared to 'Matilde' ($p<0.05$) and 'Attica' ($p<0.01$) varieties. Also, Attica had the lowest values of the fertility indices. Similar results regarding the fertility of the 'Attica' variety were also reported by Mattheou et al., 1995.

Full maturity period. The earliness of production is an essential characteristic in the competitive table grape market, which decisively influences the income of the vine growers (Colapietra M., 2004). In the conditions of the temperate-continental climate in Romania, table grapes ripen between July 15 and October 30 (Olteanu et al., 2002). In the

experimental conditions, full maturity was achieved starting from July 28 ('Cardinal' and 'Black Magic') until September 10 at the latest ('Alphonse Lavallée'). The 'Victoria' variety, particularly appreciated for the precocity of ripening and the commercial value of the grapes (Gougoulias et al., 2015; Ferrara et al., 2017), reaches full maturity in the vine-growing areas in Romania starting from the 2nd-3rd decade of August (Bucur et al., 2018; Lepădatu et al., 1986). It should be noted that in the conditions of the south-west of Romania (Plenita vineyard), the Victoria variety makes good use of its precocity of full ripening, having an advance of at least one week compared to other cultivation areas in our country. During the study period, the 'Attica' seedless variety reached full maturity at the earliest on August 14 and at the latest on August 24, while the 'Matilde' variety reaches maturity at the earliest on August 25 (Table 3).

Table 3. The agrobiological and phenological characteristics (2019-2021)

Variety	Percentage of fertile shoots (%)	Bud viability*	A.f.i.	R.f.i	Full maturity Calendar
'Cardinal'	71.87 ± 8.37^{cd}	70.73±10.96	1.59 ± 0.22^{abc}	1.15 ± 0.21^{a}	28 Jul. - 02 Aug.
'Victoria'	87.49 ± 7.39^{a}	82.11±8.25	1.73 ± 0.17^{ab}	0.97 ± 0.15^{ab}	06- 09 Aug.
'Muscat Hamburg'	66.59 ± 6.82^{cd}	74.84±10.28	1.30 ± 0.16^{cd}	0.76 ± 0.16^{b}	25-30 Aug.
'Alphonse Lavalée'	68.63 ± 6.78^{cd}	75.13±11.84	1.46 ± 0.16^{bcd}	0.89 ± 0.19^{ab}	02-10 Sept.
'Black Magic'	84.11 ± 7.20^{ab}	77.41±11.89	1.79 ± 0.13^{a}	1.18 ± 0.20^{a}	28 Jul. – 02 Aug.
'Matilde'	73.84 ± 7.71^{c}	79.94±12.31	1.43 ± 0.17^{bcd}	0.80 ± 0.15^{ab}	25 Aug. – 04 Sep.
'Attica'	60.86 ± 6.84^{de}	84.9 ± 11.87^{NS}	1.25 ± 0.12^{cd}	0.74 ± 0.13^{b}	14-24 Aug.

Note: Means±SD; Means separation by HSD Tukey`s test at $p\leq 0.05$; Means with the same superscript are not statistically significant; *at TNn = -11.8°C (dormant season 2018/2019)

Quantitative and qualitative characteristics. The size of bunches and berries is a valuable characteristic in the appreciation of table grapes, increasing their commercial value. 'Attica' and 'Cardinal' had the largest bunches as length, while 'Victoria' and 'Matilde' presented the largest bunches as width. However, a reduced variability of bunches length (CV%< 10%) can be observed in the 'Black Magic', 'Matilde' and 'Attica' (Table 4). 'Victoria' stood out with the longest berries, the differences being significant compared to the rest of the varieties ($p<0.01$). It can be noted that in all varieties the berries have low width variability (CV≤ 10%). In addition, the shape is typical for these varieties (OIV, 2009b, Colapietra M. et al., 2008), the berry length/width index being a specific characteristic of the variety.

Marketable fruit yield together with the moment of availability on the market, are key factors in terms of the profitability of a table grape variety (Zhou et al., 2015). The highest average yields per vine were recorded for the 'Attica' seedless variety (3.74 kg/vine), followed by the 'Black Magic' and 'Victoria' varieties (Table 5). There is a medium variability of the grape yield in the context of an important variability of bunches and berries weight ('Muscat Hamburg', 'Matilde' and 'Alphonse Lavalée'). The marketable fruit yield variability can be explained, among others, by the fact that excesses of abundant precipitation were recorded in a short period of time (for example in June 2019-139 mm), making it difficult to control the diseases on the one hand and affecting pollination in some varieties on the other hand, with damages on quantitative and qualitative production. Another cause could even be the lack of irrigation, in the context of the semi-arid nature of the growing season.

Table 4. Morphometric characteristics of bunch and berry at full maturity (2019-2021)

Variety	Bunch length (mm)	CV%	Bunch Width (mm)	CV%	Berry length (mm)	CV%	Berry Width (mm)	CV%	Lenght/ Widht berry	CV%	Berry Shape
'Cardinal'	227.75±29.12^{a}	12.79	160.43±12.33^{ab}	7.69	24.19±2.07^{bc}	8.55	23.35±2.01^{a}	8.61	1.04±0.09^{d}	8.65	Globose
'Victoria'	203.49±21.44^{ab}	10.54	182.43±27.93^{a}	15.30	27.51±2.9^{a}	10.54	21.20±1.26^{bc}	5.94	1.31±0.13^{b}	9.92	Broad/narrow ellipsoid
'Muscat Hamburg'	179.75±20.80^{b}	11.57	149.19±14.78^{ab}	9.91	18.72±2.12^{e}	11.32	16.85±1.37^{ef}	8.13	1.11±0.10^{cd}	9.00	Globose/ovoid
'Alphonse Lavalée'	153.18±17.23^{bc}	11.25	136.56±15.44^{b}	11.31	21.83±2.65^{d}	12.13	21.45±1.20^{b}	5.59	1.02±0.12^{d}	11.76	Globose
'Black Magic'	207.02±13.20^{ab}	6.37	128.52±14.26^{b}	11.09	24.9±2.50^{bc}	10.04	17.66±1.04^{de}	5.89	1.41±0.15^{a}	10.63	Obtuse ovoid
'Matilde'	212.25±20.60^{ab}	9.70	170.27±16.05^{ab}	9.43	24.12±2.46^{bc}	10.20	20.13±1.86^{c}	9.24	1.20±0.12^{c}	10.00	Ovoid
'Attica'	232.43±18.28^{a}	7.86	169.33±16.78^{ab}	9.91	25.31±1.97^{b}	7.78	18.68±1.35^{d}	7.23	1.36±0.11^{ab}	8.08	Narrow ellipsoid

Note: Means±SD; Means separation by HSD Tukey`s test at p≤ 0.05; Means with the same superscript are not statistically significant.

Table 5. Quantitative characteristics of grape production at full maturity (2019-2021)

Variety	Bunch Weight (g)	CV%	Berry Weight (g)	CV%	Marketable fruit yield (kg/vine)	CV%
'Cardinal'	398.92±47.68^{abc}	11.95	8.49±1.21^{a}	14.25	2.64±0.17^{c}	6.43
'Victoria'	439.44±45.58^{abc}	10.37	8.21±1.07^{ab}	13.03	3.13±0.22^{abc}	7.03
'Muscat Hamburg'	267.05±48.53^{bcd}	18.17	4.03±0.49^{f}	12.16	2.99±0.40^{bc}	13.38
'Alphonse Lavalée'	324.77±54.93^{bc}	16.91	7.59±1.05^{bc}	13.83	2.88±0.42^{bc}	14.58
'Black Magic'	365.04±48.45^{abc}	13.27	5.61±0.58^{d}	10.34	3.44±0.26^{ab}	7.56
'Matilde'	494.59±93.40^{a}	18.88	6.82±1.02^{bc}	14.95	2.65±0.42^{c}	15.85
'Attica'	465.15±40.95^{a}	8.80	4.81±0.36^{e}	7.48	3.74±0.31^{a}	8.29

Note: Means±SD; Means separation by HSD Tukey`s test at p≤ 0.05; Means with the same superscript are not statistically significant.

Ensuring water through irrigation, especially for table grapes, is a way to counteract the effects of drought and ensure regular production (Satisha et al., 2006), various studies using yield and quality of grape production as indicators to characterize the reaction of different cultivars in drought conditions (Chaves et al., 2007). Studying the effect of a three variant pruning used for 'Black Magic' variety, in Boznia Herzegovina (3 x 1.2 m vine spacing, Moser cordon training system), Delic et al. (2017) concluded that the best results of the production (7.73-12.38 kg/vine) and fertility were obtained for the 40 buds/vine. Similar results were found when analyzing the positive influence of growth for load of buds/ vine on the productivity of the Black Magic in Republic of Moldova by Godoroja et al. (2020). According to the commercial quality standards developed by the Working Party on Agricultural Quality Standards of the United Nations Economic Commission for Europe (UNECE, 2017) and OIV Resolution VITI 1/2008 (OIV, 2008), in order to satisfy the maturity requirements, the grape must have obtained a refractometric index of at least 16°Brix. For white/rose table grape varieties, fruits with a refractometry index lower than 16°Brix are accepted, provided that the sugar (expressed in g/L soluble sugars)/acid (expressed in gL^{-1} tartaric acid) ratio is at least equal to 20/1 if the Brix level is greater than or equal to 12.5° and lower than 14° Brix. For red colour table grape varieties, the grapes with a Brix degree equal to or above 12.5 and below 16° Brix, must present a minimum sugar/acid ratio of 20/1 to be considered as ripe (OIV, 2008).

The highest SSC content was recorded in the 'Matilde' and 'Muscat Hamburg', the differences being significant compared to the early ripening varieties. Among the early ripening varieties, 'Black Magic' recorded the highest sugar content and a balanced SSC/TA ratio, however, the differences are not statistically significant compared to 'Cardinal' and 'Victoria' (Table 6). The 'Attica' seedless variety recorded an average SSC of 17.03° Brix in the context of an AT of 5.62 gL^{-1} tartaric acid (Table 6).

It can be appreciated that all the varieties have ensured a balanced taste given by the SSC/TA, the maturity index being in agreement with the quality standards regarding the maturity requirements of the table grape varieties sold in the EU.

Table 6. Biochemical characteristics of grapes (2019-2021)

Variety	SSC °Brix	AT gL^{-1} tartaric acid	Maturity Index SSC/TA
'Cardinal'	14.11 ± 0.88^{bcd}	4.60 ± 0.36^{cd}	28.57 ± 2.24^{ab}
'Victoria'	15.26 ± 0.93^{bc}	4.96 ± 0.62^{c}	31.23 ± 3.82^{ab}
'Muscat Hamburg'	17.70 ± 0.86^{a}	6.08 ± 0.38^{ab}	32.25 ± 2.86^{ab}
'Alphonse Lavalée'	15.81 ± 1.04^{abcd}	6.65 ± 0.64^{a}	24.35 ± 3.60^{b}
'Black Magic'	15.47 ± 1.16^{bc}	5.10 ± 0.41^{c}	33.38 ± 6.43^{ab}
'Matilde'	17.85 ± 1.13^{a}	4.82 ± 0.39^{c}	37.53 ± 4.96^{a}
'Attica'	17.03 ± 0.94^{abc}	5.62 ± 0.56^{bc}	31.61 ± 3.68^{ab}

Note: Means±SD; Means separation by HSD Tukey`s test at $p\leq 0.05$;
Means with the same superscript are not statistically significant.

CONCLUSIONS

The varietal renovation and the promotion on the market of new table grape varieties (seeded and seedless), especially with early and late harvest, good yield, which ensures the staggered consumption over the longest period of time, are essential for increasing the competitiveness and efficiency of Romanian producers and simultaneously, ensuring consumer satisfaction. In the conditions of a low supply and high demand for table grapes at the end of July -middle of August in our country, the good productions, early ripening and availability on the market of the 'Victoria', 'Black Magic' seeded varieties and 'Attica' seedless variety, represents a high market opportunity for Romanian table grape producers.

There are improvements to be made for producing a good yield of high-quality fruit in these varieties, therefore, we consider it is necessary to continue the research in order to achieve a balance between vegetative growth

and fruiting through appropriate cultivation practices (optimal load of buds/vines, number of buds/cane, number of inflorescences/vine, summer pruning, irrigation, control of diseases and pests etc.).

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