Scientific Papers. Series B, Horticulture. Vol. LXX, No. 1, 2026
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

STUDY ON THE CARBOHYDRATE RESERVE OF SOME ROMANIAN ANCESTRAL VINE CULTIVARS IN ODOBEŞTI VINEYARD, VRANCEA COUNTY

Marioara PUŞCALĂU, Ionica BOSOI, Alina Camelia DÎRLOMAN,

Research and Development Station for Viticulture and Oenology Odobeşti,
61 Ştefan cel Mare Street, 625300, Odobeşti, Romania

Corresponding author email: oana_boss2002@yahoo.com

Abstract

The carbohydrates are produced by the leaves and stored in the form of starch and soluble sugars in the perennial organs of the vine. The carbohydrate reserve plays an essential role in the growth process of the vine, being the main source of carbon necessary for the start of vegetation in the following season. This paper evaluates the state of the carbohydrate reserve in the vines during the vegetative dormancy period of some ancestral Romanian grape cultivars in the climatic conditions of the Odobeşti vineyard, Vrancea. Five old cultivars that were part of the traditional assortment of the vineyard were studied: 'Galbenă de Odobeşti', 'Cruciuliţă', 'Pârciu', 'Gordin' and 'Razachie albă'. The content of soluble sugars, starch content, and the amount of total carbohydrates were determined by the anthrone reagent method. Under the climatic conditions of the 2024 wine year, the analyzed cultivars presented a sufficient carbohydrate reserve for the first vegetation phenophases of the 2025 wine year, two of them being classified as very well matured, having a total carbohydrate content of over 18 g 100 g $^{-1}$ DM.

Key words: *grapevine, total carbohydrates, soluble sugars, starch.*

INTRODUCTION

Monitoring carbohydrate reserves (mostly starch, but also soluble sugar) in grapevines during dormancy is important because carbohydrate reserves will influence shoot growth and reproductive development in the following season (Bennett et al., 2005). Carbohydrates are produced by the leaves and stored as starch and soluble sugars (mainly glucose, fructose and sucrose) in perennial organs (Bennet et al., 2005; Pellegrino et al., 2014; Călugăr et al., 2022). In the literature, the state of carbohydrate reserves in different parts of plants has been described by various authors (Warmund et al., 1986; Koblet and Perret, 1990; Candolfi-Vasconcelos et al., 1994; Zapata et al., 2004; Schreiner et al., 2012; Zufferey et al., 2012; Vaillant-Gaveau et al., 2014; Cimpoi et al., 2020; Muntean et al., 2023).

In wood, starch concentrations are higher than those of sugars during the growing season, but some of the starch is converted to sugars before the vegetative dormancy period to help protect the vine from cold damage during winter (Noronha et al., 2018; Călugăr et al., 2019; Popova, 2021). Shoot maturation is a physiological process of accumulation of reserve substances, which is highlighted in autumn by the change in bark color and marks the transition from the active vegetation period to the vegetative rest period (Alexandrescu et al., 1994). The process of shoot maturation begins in mid-August, with the slowdown in growth, from the base of the shoots and gradually advances towards their tip. Along the shoot, there is a maturation gap, in the sense that the internodes at the base accumulate a greater amount of carbohydrates than those oriented towards the tip of the shoot. The maturation process ends with the fall of the leaves; therefore, at the end of the vegetation period, the tips of the shoots remain unripe, often being affected by early frosts in autumn (Ţârdea and Dejeu, 1995). The dynamics of carbohydrate reserves in perennial grapevine organs are mainly determined by growth and maintenance requirements at certain developmental stages. This balance between carbon supply and demand is influenced by manageable factors such as grape yield, trunk size, and water supply, as well as by limiting climatic factors such as temperature during the growing season, which affect photosynthesis and therefore the net

carbon assimilation capacity (Holzapfel et al., 2010). Lighter pruning generally leads to a higher proportion of old wood and higher yields (Clingeleffer and Pellegrino, 2006). Climate is a major interactive factor influencing the dynamics of carbohydrate reserves in perennial tissues, in addition to crop load (Holzapfel and Smith, 2012). The concentration of soluble carbohydrates in the trunk has been shown to be negatively correlated with average air temperature (Zufferey et al., 2012). Warm temperatures are likely to have a negative impact on the carbon balance through faster canopy development and improved respiration rates, while the source activity (assimilation rate) may stabilize (Schultz, 2000; Lebon et al., 2004).

This study aims to evaluate the carbohydrate content in the cords (the most reliable laboratory indicator for assessing the degree of wood maturation) of five ancestral grapevine varieties under the conditions of the 2024 wine year in the Odobești wine area, in order to anticipate the evolution of the vegetation period in the 2025 wine year.

MATERIALS AND METHODS

The study was conducted during the vegetative rest period in the winter of 2024-2025. Five ancestral Romanian grape cultivars were investigated: four cultivars for wine grapes (′Galbenă de Odobești′, ′Cruciuliță′, ′Pârciu′, ′Gordin′) and one cultivar for table grapes - ′Razachie albă′ grafted on the ′Berlandieri x Riparia Teleky 4B SO4-4′ rootstock, located within the Ampelographic Collection of the Research and Development Station for Viticulture and Oenology Odobești.

The Ampelographic Collection was established in 2012, within the experimental base no. 1 Odobești (45°45′48”N; 27°04′04”E). The soil is of medium leached chernozem type, with an average humus content (2.0-2.3%) and a good supply of nutrients; the slope of the land is 1-2% with a southeast exposure. The planting density is 4132 vines/ha (2.2 m × 1.1 m), and the form of the trunks is semi-high; the pruning system – mixed; the type of pruning – multiple Guyot, with the load distributed over 3 fruiting rings consisting of 3 canes with 8-9 eyes and 3 fruiting cones with 2-3 eyes.

To determine the carbohydrate content, annual cane samples were collected from each cultivar (in three repetitions) on January 21, 2025. The determined parameters included cane diameter, water content, and cane carbohydrate content (sugars, starch, and total carbohydrate content). The diameter of canes was measured with a caliper; 24 measurements were made for each sample. The water content of canes was determined using the oven-drying method at a temperature of 55°C to constant mass. The canes were cut into pieces of approximately 2 cm and dried in a drying oven (SLN STD 115, POL EKO Aparature sp.j, Poland), at 55˚C, for approximately 72 hours (until constant mass). Then, the samples were ground, sieved (sizes of max. 0.7 mm), packaged and labeled accordingly, and stored at room temperature until analysis (Figure 1).



Figure 1. Samples prepared for analysis

The degree of maturation of the samples was assessed by determining the total carbohydrate content (TCH) using the colorimetric method adapted from Dubois et al. (1956). The principle of the method consists in the extraction of sugars with ethyl alcohol and the extraction of starch with perchloric acid, under determined conditions, and measuring the color intensity after treating the extracts with the anthrone reagent.

The measurement of color intensity was performed spectrophotometrically using a UV/VIS spectrophotometer (Specord Plus 200, Analytik Jena, Konrad, Germany) at a wavelength of 620 nm. The total carbohydrate content (TCH) of the samples sums the sugar and starch content, expressed as glucose (in



Figure 2. Aspects regarding the extraction and preparation of starch and soluble sugar solutions for the determination of carbohydrates in canes

grams) and expressed as a percentage of dry mass (DM), and the results obtained were evaluated as follows:

- TCH < 12 g $100g^{-1}$DM - very poorly matured
- TCH between 12-14 g $100g^{-1}$DM - poorly matured
- TCH between 14-16 g $100g^{-1}$DM - matured
- TCH between 16-18 g $100g^{-1}$DM - well matured
- TCH > 18 g $100g^{-1}$DM - very well matured

The data were analyzed using analysis of variance (Anova) and the Student's t-test ($p \leq 0.05$) via Microsoft Excel; Data Analysis was performed to highlight significant differences among the analyzed cultivars.

RESULTS AND DISCUSSIONS

Climatic conditions. The evolution of the thermal regime and precipitation in the viticultural ecosystem of the Odobești vineyard in the 2024 wine year is presented in Table 1. From a thermal and hydrological point of view, the 2024 wine year was considered one of the warmest and driest years in the last decade. The thermal regime of the vegetation period was deeply excessive: the average air temperature (21.4ºC), the average maximum temperatures (27.9ºC) and the average minimum temperatures in this period (15.3ºC) recorded values much higher than the multiannual data for these elements (18.2ºC, 24.6ºC, and 12.5ºC, respectively). During this period, 71 days with maximum temperatures above 30ºC were recorded, of which 24 days had temperatures above 35ºC. The total amount of precipitation recorded during the vegetation period was 222.1 mm, representing only 64.6% of the multiannual amount (343.7 mm). Only 7 days with precipitation greater than 10 mm were recorded during this period. During the vegetative dormancy period 2024-2025, in the Odobești wine-growing area, the lowest temperatures were recorded for very short periods at the end of February (- 10.0…-12.0°C), far from the frost resistance of the vine (-15±3°C).

From a thermal point of view, the dormancy period associated with the winter of 2024-2025 benefited from excess average air temperature values in December and January and deficit values for November and February, compared with multiannual values.

Table 1. Main climatic conditions during the grapevine growing season and the dormancy period (Odobești, April 2024 - February 2025)

Climate parameters	2024									2025	
	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II
Average temperature (ºC)	15.5	16.6	24.2	26.8	25.4	19.6	12.6	4.6	2.7	3.3	-1.6
Temp. Min. abs.	4.2	6.2	14.3	15.2	16.8	9.1	0.5	-5.0	-4.6	-5.8	-11.7
Temp. Max abs.	32.1	28.8	35.9	40.7	35.8	33.6	25.3	20.7	13.0	15.5	10.9
Precipitation (mm)	33.9	28.8	50.4	51.8	24.0	57.3	19.5	32.9	96.5	9.4	4.3

With the exception of December, the rainfall regime during this period was deficient compared with multiannual precipitation amounts for this interval.

Given the fact that in 2024 the grape production ranged between 2.26 kg/vine for 'Pârciu' and 4.05 kg/vine for 'Razachie albă', the analyzed cane samples recorded a normal humidity level for the period in which the canes were collected, oscillating around 42%. The lowest humidity level, 40.51%, was observed for the 'Pârciu' sample, and the highest humidity level, 44.94%, was recorded for 'Gordin' samples (Table 2).

The canes diameter ranged between 6.72 mm for the 'Razachie albă' sample and 8.12 mm for the 'Pârciu' sample. The total carbohydrate content varied between 12.89 g 100g $^{-1}$ DM for 'Gordin' variety and 24.39 g 100g $^{-1}$ DM for 'Cruciuliță' variety; values that are above the threshold of 12 g 100g $^{-1}$ DM, which, according to STAS 220-10/85 allows the material to be used for propagation.

Table 2. Results regarding cane water content, diameter and grape yield obtained in 2024

Crt. no.	Ancestral grape cultivar	Humidity [%]	Diameter [mm]	Yield [kg/vine]
1.	'Galbenă de Odobești'	43.12	7.78	3.09
2.	'Cruciuliță'	41.70	7.16	3.93
3.	'Pârciu'	40.51	8.12	2.26
4.	'Gordin'	44.94	6.89	3.76
5.	'Razachie albă'	43.08	6.72	4.05

The values obtained for the total carbohydrate reserve place the samples from 'Gordin' and 'Razachie albă' in the poorly matured category, the canes from 'Galbenă de Odobești' well-matured category, and the samples from 'Cruciuliță' and 'Pârciu' very well-maturedmatured category (Table 3).

Table 3. Results regarding the carbohydrate content in canes of Romanian ancestral cultivars (Odobești, 2024-2025)

Crt. No.	Ancestral grape cultivar	Soluble sugars content, [g 100g $^{-1}$ DM]	Starch content, [g 100g $^{-1}$ DM]	Total carbohydrate content, [g 100g $^{-1}$ DM]	Interpretation
1.	'Galbenă de Odobești'	8.94	8.50	17.44	well matured canes
2.	'Cruciuliță'	8.49	15.90	24.39	very matured canes
3.	'Pârciu'	8.59	10.49	19.08	very matured canes
4.	'Gordin'	5.56	7.33	12.89	poorly matured
5.	'Razachie albă'	7.18	6.55	13.73	poorly matured

The distribution of total carbohydrate content along the length of the canes (base, middle, and top) highlights higher total carbohydrate reserves in the middle and base areas.

Regarding the content of soluble sugars, 'Gordin' and 'Razachie albă' samples recorded a lower sugar content ranging between 5.56 g 100g $^{-1}$ DM and 7.18 g 100g $^{-1}$ DM (Figure 3).

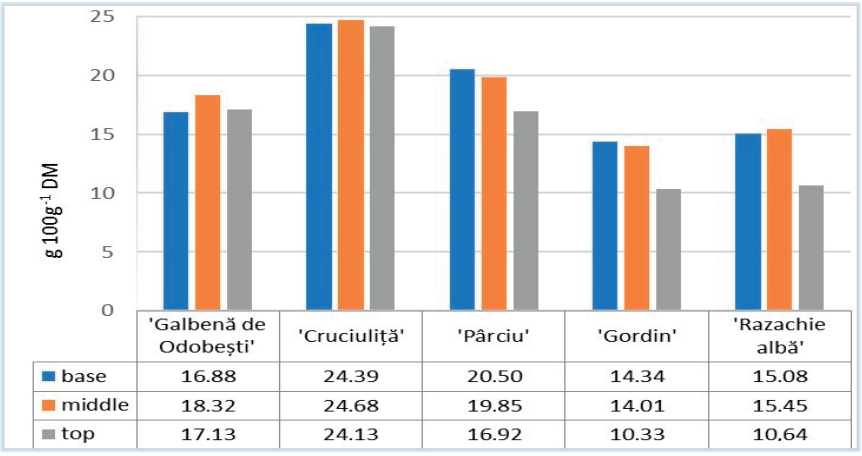

Figure 3. Distribution of total carbohydrate reserves across the canes (Odobești, 2024-2025)

The samples from 'Galbenă de Odobești', 'Pârciu' and 'Cruciuliță' cultivars recorded significantly higher and relatively similar sugar content values ranging between 8.94 and 8.49 g 100g $^{-1}$ DM.

The distribution of the soluble sugar reserve along the length of the canes shows higher amounts of soluble sugars in the top area for the 'Cruciuliță' and 'Pârciu' samples (11.34 g 100g $^{-1}$ DM, respectively 8.95 g 100g $^{-1}$ DM) and in the middle area for 'Galbenă de Odobești' (9.88 g 100g $^{-1}$ DM), 'Gordin' (6.37 g 100g $^{-1}$ DM) and 'Razachie albă' samples (8.61 g 100g $^{-1}$ DM) (Figure 4).

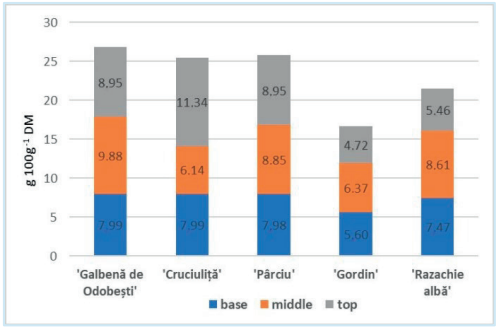

Figure 4. Distribution of the soluble sugar across the canes (Odobești, 2024-2025)

Compared to the soluble sugar reserve, the starch content in the canes varied within wider limits, with values ranging between 6.55 and 15.90 g 100g $^{-1}$ DM. The differences are significant among most of the analyzed samples, with the highest starch content being recorded for the 'Cruciuliță' cultivar, followed by 'Pârciu', 'Galbenă de Odobești' and 'Gordin'. A lower starch content was determined in the 'Razachie albă' (6.55 g 100 g $^{-1}$ DM).

The distribution of starch reserves along the canes shows higher amounts accumulated in the basal area for the 'Galbenă de Odobești', 'Pârciu', 'Gordin' and 'Razachie albă' samples (between 7.61 g 100 g $^{-1}$ DM and 12.52 g 100 g $^{-1}$ DM) and in the middle area for 'Cruciuliță' sample (18.53 g 100g $^{-1}$ DM) (Figure 5).

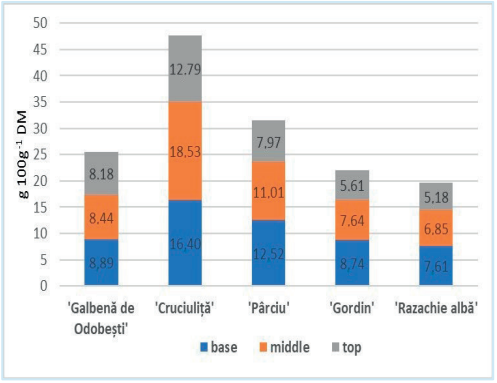

Figure 5. Distribution of the starch across the canes (Odobești, 2024-2025)

The statistical interpretation of the experimental data obtained for the total carbohydrate content (TCH) and for the starch content of the canes, based analysis of variance (Anova test), shows significant and highly significant differences between the analyzed cultivars, the value of the parameter P (0.000102, respectively 0.00086) being much lower than P<0.05 (Table 4).

Table 4. Statistical interpretation of experimental data obtained through analysis of variance (Anova test)

Source of Variation	SS	df	MS	F	P-value	F crit
Carbohydrate content in canes						
Between Groups	256.7518	4	64.18796	19.52082	0.000102	3.47805
Within Groups	32.88179	10	3.288179			
Total	289.6336	14				
Starch content						
Between Groups	168.3687	4	42.09274	11.69843	0.00086	3.47805
Within Groups	35.9810	10	3.59810			
Total	204.349	14				

The significance of the differences between the grapevine cultivars studied regarding the total carbohydrate content in the canes was established with the Student's t-test via Microsoft Excel - Data Analysis; the calculated P values being presented in Table 5.

Regarding the total carbohydrate content, according to the P > Pcritical value, the sample

from the 'Cruciuliță' presents significant positive statistical differences compared to the other analyzed cultivars, and the 'Pârciu' sample also differs significantly from the 'Gordin' and 'Razachie albă' samples. The 'Galbenă de Odobești' sample also differs significantly from 'Gordin'.

Table 5. Significance of differences in total carbohydrate content (Student's t-test probability value, P critical <0.05)

Cultivar	'Galbenă de Od.'	'Cruciu -liță'	'Pârciu'	'Godin'	'Razachie albă'
1	0				
2	0.000122*	0			
3	0.238291	0.008841*	0		
4	0.028622*	0.000885*	0.021559*	0	
5	0.081950	0.002361*	0.047602*	0.700872	0

The significance of the differences between the studied grapevine cultivars in terms of total starch content in the canes, established with the Student's t-test, are presented in Table 6.

Table 6. Significance of differences in starch content (Student's t-test probability value, P critical <0.05)

Cultivar	'Galbenă de Od.'	'Cruciu -liță'	'Pârciu'	'Godin'	'Razachie albă'
1	0				
2	0.011809*	0			
3	0.215391	0.065106	0		
4	0.280145	0.010893*	0.122858	0	
5	0.058944	0.006806*	0.060078	0.538302	0

Regarding starch content, according to the P>Pcritical value, the sample from 'Cruciuliță' shows significant positive statistical differences compared with the samples 'Galbenă de Odobești' (P=0.011809), 'Gordin' (P=0.010893) and 'Razachie albă' (P=0.006806).

The relationship between the humidity content of the canes and the carbohydrate content was established by calculating the correlation coefficient (r), and the straight line and the regression equation were represented (Figure 6). From the graphic representation, it is observed that the relationship between the two variables is linear and indirect (negative), with an increase in the humidity content of the canes leading to a decrease in the total carbohydrate content. The value of the coefficient of determination R^2 (0.5152) indicates a significant dependence between the two parameters.

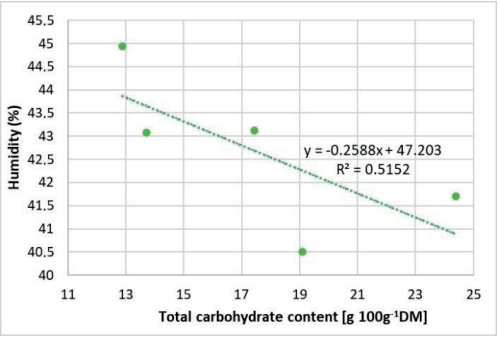

Figure 6. Correlation between total carbohydrate content and cane humidity during the dormancy period

The relationship between the humidity content of the canes and the content of soluble sugars was established by calculating the correlation coefficient (r), and the regression equation shows that the relationship between the two variables is linear and indirect (negative), with an increase in the humidity content of the canes leading to a decrease in the content of soluble sugars. The value of the coefficient of determination, R2 (0.5982) indicates a significant dependence between the two parameters (Figure 7).

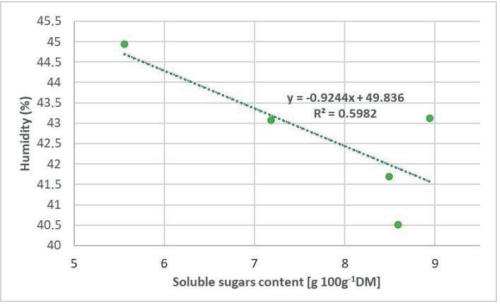

Figure 7. Correlation between soluble sugar content and cane humidity during the dormancy period

Grapevine cultivars that have a genetic tendency to contain more carbohydrates also tend to be more resistant to frost in winter. Scientific studies have shown that low bud viability in several grapevine cultivars is also due to low carbohydrate content, with high bud viability being correlated with a high amount of carbohydrates in the canes (Vasudevan, 1997).

Starch accumulation in grape canes and buds is associated with dormancy. Starch breakdown and the subsequent increase in sugar content are associated with cold hardiness (Rubio et al., 2015). The results of the present study are consistent with the data available in the literature. The shoot or cane is considered mature if, at the end of the vegetation period, the starch content is greater than 10 g 100 g^{-1}DM or the total carbohydrates are greater than 12 g 100 g^{-1}DM (Irimia, 2012). Holzapfel et al. (2010) consider that the shoot is fully mature (reaches a maximum degree of lignification) if, at the time of leaf fall, it has a total carbohydrate content of 19 g 100 g^{-1}DM.

CONCLUSIONS

From a thermal and hydrological point of view, the 2024 wine year was considered one of the warmest and driest years in the last decade.

Under the climatic and technological conditions of the 2024 wine year, during the vegetative dormancy period 2024-2025, the five ancestral Romanian cultivars recorded a total carbohydrate content between 12.89 and 24.39 g $100g^{-1}$ $_{DM,}$ with higher values at the base and middle of the cane.

The samples of ′Gordin′ and ′Razachie albă′ showed a lower carbohydrate reserve (12.89 and 13.73 g $100g^{-1}$ DM, respectively), values that indicate poor maturation of the canes.

A very good maturation of the canes was found in the samples of ′Pârciu′ and ′Cruciuliță′, which accumulated a total amount of carbohydrates of 19.08 g $100g^{-1}$ DM and 24.39 g 100 g^{-1} DM, respectively.

The analyzed cane samples recorded a normal humidity level for the period in which they were collected, which ranged between 40.51%, for the ′Pârciu′ samples and 44.94%, for the ′Gordin′ samples.

The soluble sugar content recorded lower values in Gordin' samples (5.56 g 100 g^{-1} DM) and higher values in the samples from ′Galbenă de Odobești′, ′Cruciulița′, ′Pârciu′ and ′Razachie albă′ (between 7.18 and 8.94 g 100 g^{-1} DM), with higher values at the top and middle of the cane.

The starch content recorded high values for the samples from the ′Pârciu′ and ′Cruciulița′ (10.49 g 100 g^{-1} DM, respectively 15.90 g $100g^{-1}$ DM) and lower values for the samples from ′Razachie albă′, ′Gordin′ and ′Galbenă de Odobești′ (between 6.55 and 8.50 g 100 g^{-1} DM, with higher values at the base and middle of the cane.

The statistical interpretation of the experimental data obtained for total carbohydrate content (TCH) and starch content in the strings shows significant and very significant differences between the analyzed cultivars ($P<0.05$).

The results of the present study indicate that, between the studied wine and table cultivars, depending on the production direction, there is a significant difference in terms of starch content. The significant differences between the analyzed wine cultivars also show the different potential of genetic determinants for wood ripening, which can be correlated with frost resistance.

A negative correlation was revealed between cane humidity and total carbohydrate and soluble sugar content, while cane diameter and yield had no influence on carbohydrate content.

ACKNOWLEDGEMENTS

The work was carried out within the projects S.P. ADER 6.3.12/20.07.2023 and ADER 6.1.7/18.07.2023, funded by the Ministry of Agriculture and Rural Development of Romania through the Sectorial Plan for Research and Development in the Agricultural Field – ADER 2026.

REFERENCES

Alexandrescu, I.C., Oșlobeanu, M., Jianu L. & Pițuc, P. (1994). Mică enciclopedie de viticultură. Editura *Glasul Bucovinei*, Iași, ISBN 973-96800-1-1.

Bennett, J., Jarvis, P., Creasy, G.L. & Trought, M.C.T. (2005). Influence of defoliation on overwintering carbohydrate reserves, return bloom, and yield of mature Chardonnay grapevines. *American Journal of Enology and Viticulture*, 56: 386-393.

Candolfi-Vasconcelos, M. C., Candolfi, M. P. & Koblet, W. (1994). Retranslocation of carbon reserves from the woody storage tissues into the fruit as a response to defoliation stress during the ripening period in *Vitis vinifera* L. *Planta*, 192, 567-573.

Călugăr A., Pop, N., Farago, M., Babeș A., Bunea, C.I., Hodor, D. & Ciobanu, F. (2010). Buds viability and carbohydrates canes content of some varieties created at S.C.D.V.V. Blaj during winter 2009-2010. *Scientific Papers*, *Series B. Horticulture*, *LIV*, 548-553.

Călugăr, A., Cordea, M. I., Babeș, A., Fejer, M., Comșa, M. & Popescu, D. (2022). The measurements of starch and total sugars content in some grapevine varieties

(*Vitis vinifera* L.) during dormancy through different methods. *Scientific Papers. Series B. Horticulture*, *LXVI (1*), 229-236.

Călugăr, A., Cordea, M. & Babeş, A. (2019). Dynamics of starch reserves in some grapevine varieties (*Vitis vinifera* L.) During dormancy, *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture,* 76 (2), 185-192.

Cimpoi, V. I., Rotaru, L., Colibaba, L. C., Scutăraşu, E. C., Călin, I. & Alexandru, C. L. (2020). Influence of carbohydrate content on grafting in wine grape varieties 'Aromat de Iași' and 'Golia', *Scientific Papers. Series B. Horticulture, LXIV* (1), 248-254.

Clingeleffer, P. R. & Pellegrino, A. (2006). Pruning, rootstock and seasonal impacts on vine carbohydrate status, in *Proceedings of a Workshop: Vine Carbohydrate Dynamics and Source Sink Relationships*, ed. R.R. Walker (Merbein), 45–54.

Dubois, M., Gilles, G. A., Hamilton, J. K., Rober, P. A., & Smith, F. (1956). Colorimetric estimation of carbohydrates by phenol sulphuric acid method, *Analytical Chemistry*, *28*(3), 350-356.

Holzapfel, B. P., Smith, J. P., Field, S. K. & Hardie, W. J. (2010). Dynamics of carbohydrate reserves in cultivated grapevines, *Horticultural Reviews*, *37*, 143-201.

Holzapfel, B. P. & Smith, J. P. (2012). Developmental stage and climatic factors impact more on carbohydrate reserve dynamics of Shiraz than cultural practice. *American Journal of Enology and Viticulture,* 63, 333–342.

Irimia, L. M. (2012). *Biologia, ecologia și fiziologia viței de vie,* Editura Ion Ionescu de la Brad, Iași, ISBN: 978 973147-147-8.

Koblet, W. & Perret, P. (1990). Beziehung zwischen Triebwachstum, Wurzelentwicklung und Assimilatwanderung in Topfreben. *Wein-Wiss*. 45, 93-96.

Lebon, E., Pellegrino, A., Tardieu, F. & Lecoeur, J. (2004). Shoot development in grapevine (*Vitis vinifera L.*) is affected by the modular branching pattern of the stem and intra- and inter-shoot trophic competition. *Annales Botanici Fennici, 93*, 263–274.

Muntean M.D., Sîrbu A.D., Botea V., Răcoare H.S., Tomoiagă L.L., Comșa M. & Chedea, V.S., 2023, Carbohydrate reserves in some grapevine cultivars from SCDVV Blaj, *Acta Agricola Romanica*, 5(2), 72-79.

Noronha H., Silva A., Dai Z., Gallusci P., Rombolà A.D., Delrot S. & Gerós H. (2018). A molecular perspective on starch metabolism in woody tissues. *Planta, 248*, 559–56.

Pellegrino A., Clingeleffer P., Cooley N., & Walker R. (2014). Management practices impact vine carbohydrate status to a greater extent than vine productivity. *Frontiers in Plant Science*, *5*, 283.

Popova Anelia (2021). Influence of the biochemical composition of vine canes on cold resistance of buds in different 'Syrah' clones, *Scientific Papers. Series B. Horticulture, LXV*(1), 328-333.

Rubio, S., Dantas, D., Bressan-Smith, R., & Perez, F. R. (2015). Relationship between endodormancy and cold hardiness in grapevine buds. *Journal of Plant Growth Regulation, vol. 35* (1), 266-275.

Schreiner R.P., Kerton J.N., & Zasada I.A. (2012). Delayed response to ring nematode (Mesocriconema xenoplax) feeding on grape roots linked to vine carbohydrate reserves and nematode feeding pressure. *Soil Biochemistry*, 45: 89-97.

Schultz, H. R. (2000). Climate change and viticulture: a European perspective on climatology, carbon dioxide and UV-B effects. *Australian Journal of Grape and Wine Research,* 6, 2–12.

Țârdea, C. & Dejeu, L., 1995, *Viticultură,* Editura Didactică și Pedagogică, R.A., București, ISBN 973-30-2948-3.

Vaillant-Gaveau N., Wojnarowiez G., Petit A-N., Jacquens L., Panigai L., Clément C. & Fontaine F. (2014). Relationships between carbohydrates and reproductive development in Chardonnay grapevine: impact of defoliation and fruit removal treatments during four successive growing seasons. *Journal International des Sciences de la Vigne et du Vin*, *48*, 219-229.

Vasudevan L. (1997). Anatomical developments and the role of carbohydrate or mineral nutrient deficiency in bud necrosis of Riesling grapevines. *PhD dissertation*, *Agricultural and Food Sciences, Biology,* Virginia.

Warmund, M. R., Starbuck, C. J. & Lockshin, L. (1986). Growth, cold hardiness, and carbohydrate content of 'Vidal blanc' grapevines propagated by hardwood vs. softwood cuttings. *American Journal of Enology and Viticulture, 37*, 215-219.

Zapata, C., Deléens, E., Chaillou, S. & Magné, C. (2004). Partitioning and mobilization of starch and N reserves in grapevine (*Vitis vinifera* L.), *Journal of Plant Physiology, 161*, 1031-1040.

Zufferey, V., Murisier, F., Vivin, P., Belcher, S., Lorenzini, F., Spring, J. L. & al. (2012). Carbohydrate reserves in grapevine (*Vitis vinifera* L. 'Chasselas') influence of leaf to fruit ratio. *Vitis - Journal of Grapevine Research, 51*, 103–110.