Bulgarian Journal of Agricultural Science, 28 (No 4) 2022, 662–667

Comparative study of the influence of the rootstock on the degree of drought resistance in the grapevine cultivar Kaylashki rubin

Iliyan Simeonov[1], Anatoli Iliev[1] and Simeon Krumov[2*]

[1]*Institute of Viticulture and Enology, 5800 Pleven, Bulgaria*
[2]*Institute of Agriculture, 2500 Kyustendil, Bulgaria*
[*]*Corresponding author:* sd_krumov@abv.bg

Abstract

Simeonov, I., Iliev, A. & Krumov, S. (2022). Comparative study of the influence of the rootstock on the degree of drought resistance in the grapevine cultivar Kaylashki rubin. *Bulg. J. Agric. Sci., 28 (4)*, 662–667

It was performed a comparative study on the drought resistance of the red wine cultivar Kailashki rubin, grafted on four different rootstocks. It was established that during the studied period 2017-2020 the tendency to significant warming and drought in Pleven region of Bulgaria was permanently outlined, expressed in increasing the values of the total temperature sum and reducing the total rainfall during the growing season. Under the specific climatic conditions for each year and on average for the period, in all studied cultivar-rootstock combination, water stress of different intensity was found. The performed statistical analysis of the data determines as reliable the differences in the values of the established water deficit as regards to the different rootstocks. Drought resistance, as a very important agrobiological characteristic, was the highest in the cultivar-rootstock combination Kaylashki rubin/110 Richter and the lowest in Kaylashki rubin/Berlandieri x Riparia SO 4 (control). The combination Kaylashki rubin/44-53 Malegue also appears to be very promising in terms of its response to the studied abiotic stress factor.

Keywords: Kaylashki rubin; cultivar-rootstock combination; resistance; drought

Introduction

Climate change in recent years has a specific regional dimension, but in one way or another, in all affected regions there is a negative impact of global warming among all areas of economic activity. There has been a significant increase in the continent's average temperatures, a decrease in precipitation in the southern parts of Europe and an increase in the northern part (EEA, 2012a). The number and intensity of the registered extreme hydro-climatic phenomena, such as floods, extremely high temperatures, storms, droughts, hail, etc. are increasing (EEA, 2012b).

These climatic anomalies will lead to a very serious negative impact on agriculture and natural resources, mainly in terms of reduced yields and productivity of crop production (Orlandini et al., 2008; The European Environment – State and Outlook 2010). In recent years in Bulgaria there is also a steady trend towards global warming, compared to previous periods, as well as an increase in the frequency of extreme weather events (Alexandrov et al., 2010; MEW, 2012; Rachev & Dimitrova, 2016; Rachev & Asenova, 2017; Drought Management Centre for Southeastern Europe – DMCSEE).

According to its ecological plasticity, the vine (*Vitis* L.) belongs to the group of euribionts and tolerates a wider range of changes in climatic factors. Its tolerance to temperature and water fluctuations varies widely. For this reason, it is often mistaken to believe that the vine can be successfully grown at high temperatures, on poor and dry soils and without irrigation (Karante, 1971). The resistance of the vine to drought is directly dependent on the soil, rootstock, cultivar and applied agricultural techniques. The rootstock protects the cultivated part of the vine plant from a number of harmful environmental conditions, giving resistance to different abiotic stress factors (Carbonneau, 1985; Ezzahouani & Williams, 1995; Kocsis et al., 1998; Boso et al., 2008). It is known that water consumption of the vine reaches its maximum during grain growth (Peacock et al., 2000; Wample, 2001; Behboudian & Singh, 2001). Before that, due to the incompletely developed leaf mass and then due to the reduction of transpiration from the aged leaves, the need for water is lower. Some of the physiological reactions of the vines to water deficit include decreased cell division and expansion, stomata closure, decreased photosynthesis, and in the worst case, cell death and dehydration (Goodwin, 2002). It has been found that at the beginning of berry ripening, mild water deficiencies can even have a positive effect by reducing the cell size, thus increasing the concentration of aromatic substances in the grapes (Smart, 1974). According to Lakso & Pool (2000) at excessive water stress begins to inhibit the develope taste of the grapes, resulting in wines with lower organoleptic qualities.

Determining the leaf water potential (Ψ) allows to point out the most resistant to this stress factor cultivars and cultivar-rootstock combinations and to determine with great accuracy the moment of irrigation at them. The leaf water potential (Ψ) is determined using an elevated pressure chamber (Scholander et al., 1965). There are 3 ways of measurement - Pre dawn leaf water potential (PLWP), Leaf water potential measured at midday (M LWP) and stem water potential (SWP). According to Deloire & Heyns (2011), these methods provide a short-term answer to the state of water stress and are influenced by the interaction between water content in the soil, climate, transpiration and cultivar. A number of authors show the importance of water deficit according to its duration on the phenological stages and quality indicators of the vine (Naor et al., 1997; Ojeda et al., 2001, 2002; Van Leeuwen et al., 2004; Deloire et al., 2004, 2005; Myburgh, 2007).

The aim of the study was to determine the influence of the rootstock on the degree of resistance to drought of the red wine cultivar Kaylashki rubin and to establish the exact moment for the implementation of hydro-ameliorative activities in the vineyard.

Material and Methods

The research work was carried out in the period 2017 - 2020 in an experimental plantation of Institute of Viticulture and Enology - Pleven, Bulgaria. The plantation was established in 2009 on an area of 2.6 da (0.26 ha), with a planting distance of 2.20 m between rows and 1.30 m inside the row. The object of study was the reaction to drought of the red wine cultivar Kaylashki rubin (Pamid x Hybrid VI 2/15) x (Gamay noir x *Vitis amurensis*) (Roychev, 2012), grafted on the following rootstocks:

American-American hybrids (Roychev, 2012)

Berlandieri x Riparia SO 4 - main for the Bulgaria (control).

Berlandieri x Rupestris 110 Rihter.

Riparia x (Cordifolia x Rupestris) 44-53 Malegue.

European-American hybrids (Roychev, 2012)

Fercal (BC_1 /Berlandieri x Colombard № 1 A/ x 333 E. M. /Cabernet Sauvignon x *Berlandieri*/.

Each cultivar-rootstock combination consists of 75 vines, divided into 4 replications of 15 vines, formed by a medium stem (0.80 m), type double Guyot training system. The pruning and loading of the vines is the same in all variants - 28 buds (winter eyes), realized with 2 fruit shoots with 8 buds and 6 knots with 2 buds each.

To determine the ecological plasticity of all studied cultivar-rootstock combination, the climatic indicators - total annual temperature sum (°C), average daily and total temperature sum in the months of July and August (°C) and rainfall during the growing season (mm) were monitored annually from a meteorological cell located in the experimental area. To determine the need of vine plants for water annually during the growing season, the hydrothermal coefficient, HTC (Selyaninov, 1928) was calculated.

The susceptibility of the studied cultivar-rootstock combinations to drought was determined by taking into account visual symptoms of moisture deficiency and leaf water potential ($\Psi_{(leaf)}$) of the vines measured at midday (Scholander et al., 1965; Naor, 1998). The visual observations of moisture deficit (leaf wilting, yellow or dead leaves, necrotic edges on the leaves, suppressed growth, withered grains in the bunches) were performed regularly, every week from the beginning of grape ripening until harvest. The $\Psi_{(leaf)}$ of the vines was determined annually, in July and /or August, during the beginning of grape ripening, using a pressure chamber (PCI, model 600). The measurements were performed at noon, when the water potential is in a relatively static position from the daily maximum deficit. Cloudless and windless days were chosen between 13.00 and 14.30 p.m. at an air temperature not higher than 35°C. Samples of 3 fully developed leaves located on the sunlit side of 5 vines of equal growth strength from each cultivar-rootstock combination were measured. The measurement of water stress was performed in negative (-) bars on the scale of Naor (1998), according to which at established pressure up to -10 bars - no stress, from -10 to -12 bars - mild stress, from - 12 to -14 bars - moderate stress, from -14 to -16 bars – high stress and higher than -16 bars - severe water stress.

Statistical processing of the experimental results was processed by the method of dispersion analysis (Dimova & Marinkov, 1999).

Results and Discussion

The values of the main climatic indicators for the studied period are presented in Table 1.

The presented data clearly show a stable increase over the years in the values of the indicator - total temperature sum (t° > 10°C). The highest value of this indicator for the studied region was reported in 2019 – 4827.1°C, which was 74.3°C higher than in 2020, 253.4°C higher than in 2018 and 398.5°C higher than in 2017. There was a tendency to increase the total temperature sum over the last four years. According to this indicator, 2019 and 2020 are the warmest for the last ten years. The values of the indicators - average daily air temperature and the total temperature sum vary within narrow limits and were within the normal range for this period. In the last two years, an increase in the average daily air temperatures for August by more than 1°C has been registered. The reported values for this month were the highest for the last 15 years.

In all years of the study there was a different uneven quantitative distribution of rainfall during the growing season. In 2017, the rainiest months were March, May, July and October, in 2018 - March, June and July, in 2019 - April, May and August, and in 2020 - March and October. The trend of the last seven years continues, the amount of precipitation in September to be significantly less than the norm for the region, and in 2019 an absolute record was set - only 3.2 mm. With some exceptions (2017 and 2020) a similar picture is observed for the month of October. The total amount of precipitation during the individual vegetations of the period 2017 - 2020 varied in a wide range (Table 2). The differences in quantitative terms were from 451.4 mm/m^2 (2019) to 759.2 mm (2017), which defines these years as relatively dry and relatively wet, respectively. The year 2020 was also dry with a rainfall of 452.8 mm. In recent years, there has been a tendency to reduce the number and total rainfall during the growing season. With a few exceptions, during the vegetation periods of 2019 and 2020, the days with registered precipitation were less than the previous four years. Against the background of less rainfall, the number of days with one-time but abundant rains increases significantly.

The supply of the vine plant with water, expressed by the hydrothermal coefficient, was different both in the studied years and in the separate months of each of them (Table 3). At the beginning and the end of the vegetation periods, during the months of April, May, June and October, the water supply of the vine (optimal value of HTC for vine = 1) is generally very good. At certain moments of these periods, critically high values of HTC were reported, in which case one can expect even unfavorable for the development of the vine influence of water and a negative manifestation of certain signs and processes. In the remaining months, most often the water supply of the vines was insufficient and they experienced water stress. During these periods, the values of HTC were low (0.41 – 0.80), and often even with critical value (0.12 – 0.31), which had an adverse effect on the development of all physiological and biochemical processes in the vine. At similar values of HTC, for the normal development

Table 1. Values of climatic indicators in the region of Institute of Viticulture and Enology - Pleven, for the period 2017–2020

Year	Total temperature sum, t°C > 10°C	Temperature sum, °C		Average daily air temperature, °C		Sum of precipitation for the vegetation period, mm
		July	August	July	August	
2017	4428.6	734.9	744.7	23.7	24.1	759.2
2018	4573.7	712.3	740.1	22.9	23.8	593.4
2019	4827.1	726.3	770.8	23.4	24.9	451.4
2020	4752.8	731.7	767.8	23.6	24.8	452.8

Table 2. Monthly amount (mm) of precipitation during the vegetation for the period 2017–2020

Month / Year	March	April	May	June	July	August	September	October
	mm	mm	mm	mm	mm	mm	mm	mm
2017	80.8	56.0	135.2	66.0	210.4	25.8	37.6	147.4
2018	90.2	38.6	38.6	170.0	189.6	21.6	19.4	25.4
2019	29.0	84.4	121.2	86.0	47.4	62.8	3.2	17.4
2020	92.4	13.2	74.2	58.4	58.6	8.6	19.8	127.6

Table 3. Hydrothermal coefficient during the vegetation for the period 2017 – 2020

Year \ Month	April	May	June	July	August	September	October
2017	1.55	2.58	0.96	2.86	0.35	0.65	3.84
2018	0.77	0.64	2.61	2.66	0.46	0.43	0.77
2019	2.33	2.31	1.47	0.65	0.69	0.53	0.41
2020	0.38	1.41	0.92	0.80	0.12	0.31	2.90

of the vines and the high quality grape production it is necessary to carry out hydromelioration activities in the vineyards.

Due to unfavorable weather conditions in July and August, 2018 (large number and amount of precipitation, cloudiness, low average daily air temperatures) no leaf water potential ($\Psi_{(leaf)}$), analyzes were performed.

During the three years of the study and on average for the period, the highest water stress was characterized by Kaylashki rubin grafted on the control (SO 4), followed by the variants grafted on the Fercal, 44-53 Malegue and 110 Richter rootstocks. In 2017, the variation was in the range from -17.0 bars (110 Richter) to -18.5 bars (SO 4), in 2019 from -10.2 bars (110 Richter) to -13.8 bars (SO 4) and in 2020 from -11.7 bars (110 Richter) to -17.0 bars (SO 4). In 2017, very high water stress was reported in all variants. In 2019, for the 110 Richter and 44-53 Malegue rootstocks, the stress was moderate, and for Fercal and SO 4 - medium. In 2020, at 110 Richter, water stress was again moderate, at 44-53 Malegue - medium, at Fercal – severe stress, and at control - very high. On average for the period, the data were similar, the cultivar-rootstock combination Kaylashki rubin/SO 4 (control) was the most sensitive to drought variant, and the cultivar-rootstock combination Kaylashki rubin/ 110 Richter was the most resistant (Table 4). According to Bogart (2013), the first irrigation for red cultivars should be applied when the leaf water potential ($\Psi_{(leaf)}$) measured at midday is from -14 to -15 bar.

From the performed mathematical analysis of the data it was established that compared to the control with good reliability are the differences in the results of the rootstock 110 Richter, and proved on the rootstock 44-53 Malegue. The scion-rootstock combination Kaylashki rubin/Fercal had a better resisted to drought compared to control Kaylashki rubin/SO 4, but without statistical evidence (Table 4).

The comparative analysis of the data between the different variants of the Kailashki rubin cultivar revealed mathematically proven differences with a positive orientation of the 110 Richter rootstock compared to the SO 4 (control), as they are very well provided, and for the Fercal rootstock - proven. There are no proven differences in drought resistance between the variants grafted on the 110 Richter and 44-53 Malegue rootstocks, but in all years and on average for the period they were always in favor of the 110 Richter rootstock. All these results and dependencies determine the cultivar-rootstock combination Kaylashki rubin/110 Richter as the most drought resistant, followed by combination

Table 4. Leaf water potential ($\Psi_{(leaf)}$, /-/ bars), for Kaylashki rubin cultivar, grafted on different rootstocks

Cultivar	Rootstocks	Leaf water potential ($\Psi_{(leaf)}$, /-/ bars)			
		2017	2019	2020	Average
Kaylashki rubin	SO4 (control)	-18.5	-13.8	-17.0	-16.43
	Ferkal	-17.6	-13.2	-15.3	-15.37 n.s.
	44-53 Malegue	-17.2	-12.0	-13.5	-14.23 +
	110 Richter	-17.0	-10.2	-11.7	-12.97 ++

GD(5.0%) = t*S~d = 1.744; GD(1.0%) = t*S~d = 2.642; GD(0.1%) = t*S~d = 4.247

Table 5. Proof of the differences in determining the leaf water potential ($\Psi_{(leaf)}$, /-/ bars), compared to the control, when comparing between the different rootstocks

Kaylashki rubin	x~	SO4 (control)		Ferkal		44-53 Malegue		110 Richter	
		difference	proof	difference	proof	difference	proof	difference	proof
SO4 (control)	-16.43	x	x	1.067	n.s.	2.200	+	3.467	++
Ferkal	-15.37	-1.067	n.s.	x	x	1.133	n.s.	2.400	+
44-53 Malegue	-14.23	-2.200	–	-1.133	n.s.	x	x	1.267	n.s.
110 Richter	-12.97	-3.467	–	-2.400	–	-1.267	n.s.	x	x

GD(5.0%) = t*S~d = 1.744; GD(1.0%) = t*S~d = 2.642; GD(0.1%) = t*S~d = 4.247

Kaylashki rubin/44-53 Malegue compared to all other variants. With good prospects, under different soil and climatic conditions, the combination Kaylashki rubin/44-53 Malegue is also characterized, as the difference and respectively the resistance to drought, compared to the control is proven to be higher (Table 5).

In all years of the study, in none of the studied cultivar-rootstock combinations no symptoms of water deficiency was observed.

Conclusions

A significant increase in the total temperature amount has been established in the last four years, and according to this indicator 2019 and 2020 were characterized as the warmest, compared to the previous ten-year period. There was also a tendency to reduce the total amount of rainfall during the growing season, as well as the number of days with registered precipitation, but significantly increase the days with one-time and heavy rainfall.

Under the specific climatic conditions for each year and on average for the period, at all cultivar-rootstock combinations were found different in intensity of water stress. The performed statistical analysis of the data determines as reliable the differences in the values of the reported water deficit in relation to the different rootstocks. Drought resistance, as a very important agrobiological characteristic, was the highest in the cultivar-rootstock combination Kaylashki rubin/110 Richter and lowest in Kaylashki rubin/Berlandieri x Riparia SO 4 (control). The combination Kaylashki rubin /44-53 Malegue also appears to be very promising in terms of its response to the studied abiotic stress factor.

References

Alexandrov, V., Simeonov, P., Kazandjiev, V., Korchev, G. & Yotova, A. (2010). Climate change. *Ed. NIMH-BAS*, 49, (Bg).

Behboudian, M. & Singh, Z. (2001). Water Relations and Irrigation Scheduling in Grapevine. *Horticultural Reviews*, *27,* 189-225.

Bogart, K. (2013). Measuring wine grape water status using a pressure chamber. http://www.extension.org/pages/33029/measuring-winegrape-water-status-using-a-pressure-chamber#.Upb_jyfRrcc.

Boso, S., Santiago, J. & Martínez, M. (2008). The influence of 110-Ritcher and SO4 rootstocks on the performance of scions of *Vitis vinifera* L. cv. Albariño clones. - Spanish *Journal of Agricultural Research*, *6 (1),* 96-104.

Carbonneau, A. (1985). The early selection of grapevine rootstocks for resistance to drought conditions. *American Journal of Enology and Viticulture*, *36 (3),* 195-198.

Deloire, A., Carbonneau, A., Wang, Z. & Ojeda, H. (2004). Vine and Water: A short review. *J. Int. Sci. Vigne Vin, 38 (1),* 1 – 13.

Deloire, A., Vaudour, E., Carey, V., Bonnardot, V. & Van Leeuwen, C. (2005). Grapevine responses to terroir, a global approach. *J. Int. Sci. Vigne Vin, 39 (4),* 149-162.

Deloire, A. & Heyns, D. (2011). The leaf water potentials: principles, method and thresholds.http://wineland.co.za/archive/index.php?option=com_zine&view=author&id=224:-prof-alain-deloire-and-drikus-heyns.

Dimova, D. & Marinkov, E. (1999). Experimental works and biometry. *Academic Publishing House of HAI*, Plovdiv, 263, (Bg).

Drought Management Centre for Southeastern Europe – DMC-SEE, http://www.dmcsee.org.

EEA (2012a). Report 12 of the European Environment Agency "Climate change, impact and vulnerability 2012 http://www.energee-watch.eu/sites/default/files/Climate%20change-%20impacts%20and%20vulnerability%20in%20Europe%202012.pdf.

EEA (2012b). Key facts and messages. http://www.eea.europa.eu/themes/climate

Ezzahouani, A. & Williams, L. (1995). The Influence of Rootstock on Leaf Water Potential, Yield, and Berry Composition of Ruby Seedless Grapevines. *American Journal of Enology and Viticulture*, *46 (4),* 559-563.

Goodwin, I. (2002). Managing water stress in grape vines in Greater Victoria. Date of access:17/02/2003.http://nre.vic.gov.au/web/root/domino/cm_da/nrenfa.nsf/frameset.NRE+Farming+and+Agriculture? OpenDocument

Karante, V. (1971). Watering the vine: In the problem of viticulture. *Zemizdat,* Sofia, 145 – 154, (Bg).

Kocsis, L., Lehoczky, E., Bakonyi, L., Szabo, L., Szoke, L. & Hajdu, E. (1998). New lime and drought tolerant grape rootstock variety. *Acta Horticulturae*, *473,* 75-82.

Lakso, A. & Pool, R. M. (2000). Drought stress effects on vine growth, function, ripening and implications for wine quality. 29th Annual New York Wine Industry Workshop, NYS Agric. Exper. Sta., 86-90. Date of access:14/02/2003.http://www.nysaes.cornell.edu/hort/faculty/lakso/PaperScans/2000scan140.pdf.

Ministry of Environment and Water (MEW) (2012). Third national plan for action for climate change for the period 2013-2020., Available at:
http://www3.moew.government.bg/files/file/Climate/Climate_Change_Policy_Directorate/Treti_nacionalen_plan_za_deistvie_po_izmenenie_na_klimata.pdf (Bg).

Myburgh, P. A. (2007). The effect of irrigation on growth, yield, wine quality and evapotranspiration of Colombar in the Lower Orange River Region. *Wynboer Technical Yearbook 2007/2008*, 59-62.

Naor, A., Gal, Y. & Bravdo, B. (1997). Crop load effects assimilation rate, stomatal conductance, stem water potential and water relations of field-grown Sauvignon Blanc grapevines. *Journal of Experimental Botany*, *48 (314),* 1675-1680.

Naor, A. (1998). Relations between leaf and stem water potentials and stomatal conductance in three field-grown woody species. *Journal of Horticultural Science and Biotechnology*, *73 (4),* 431-436.

Ojeda, H., Deloire, A. & Carbonneau, A. (2001). Influence of water deficits on grape berry growth. *Vitis*, *40 (3),* 141-145.

Ojeda, H., Andary, C., Kraeva, E., Carbonneau, A. & Deloire, A. (2002). Influence of pre- and post-véraison water deficit on synthesis and concentration of skin phenolic compounds during berry growth of *Vitis vinifera* L., cv Shiraz. *American Journal of Enology and Viticulture*, *53 (4),* 261-267.

Orlandidni, S., Nejedlik, P., Eitzinger, J., Alexandrov, V., Toulios, L., Calanca, P., Trnka, M. & Olesen, **J.** (2008). Impacts of climate change and variability on European agriculture. *Annals of the New York Academy of Sciences,* 1146, 338-353.

Peacock, W., Williams, L. & Christensen, P. (2000). Water management and irrigation scheduling. Raisin Production Manual, University of California, Agricultural & Natural Resources, *Publication No 3393*, 127-133.

Rachev, G. & Asenova, N. (2017). Current changes of the air temperature and precipitation in Bulgaria. *Annual of Sofia University,* Faculty of Geology and Geography, *110 (2),* 7-24, (Bg).

Rachev, N. & Dimitrova, D. (2016). Changes in average temperatures and precipitation in Bulgaria for the period 1995–2012. *Annual of Sofia University "St. Kliment Ohridski",* Faculty of Physics, *109*, 25, (Bg).

Roychev, V. (2012). Ampelography. *Academic Publishing House of AU-Plovdiv*, 576, (Bg).

Scholander, P., Hammel, H., Brandstreet, E. & Hemmingsen, E. (1965). Sap pressure in vascular plants. Science, *148,* 339-346.

Selyaninov, G. (1928). On agricultural climate assessment. *Works on Agricultural Meteorology, 20*, 165-177 (Ru).

Scholander, P., Hammel, H., Brandstreet, E. & Hemmingsen, E. (1965). Sap pressure in vascular plants. *Science, 148,* 339-346.

Source: „The European Environment – state and outlook 2010". Report by the European Environment Agency: http://www.eea.europa.eu/soer/synthesis/translations/evropeyska-ta-okolna-sreda-2014-sastoyanie.

Smart, R. L. (1974). Grapevine responses to furrow and trickle irrigation. *American Journal of Enology and Viticulture, 25,* 62-66.

Van Leeuwen, C., Friant, Ph., Chone, X., Tregoat, O., Koundouras, S. & Dubourdieu, D. (2004). The influence of climate, soil and cultivar on terroir. *American Journal of Enology and Viticulture, 55 (3),* 207-217.

Wample, R. (2001). Irrigation Management Strategies. Proceedings, 4th Annual Central Coast Viticulture and Enology Issues Conference "Grapevine Water Management Strategies". California State University – Fresno, Viticulture and Enology Research Center & Allan Hancock College, 71-76.

Received: **April, 26, 2021**; *Accepted*: **August, 12, 2021**; *Published*: **August, 2022**