IMPACT OF ROOTSTOCKS ON FRUIT QUALITY, MINERAL NUTRITION AND LEAF PHYSIOLOGY OF 'RED GLOBE' IN THE EAST MEDITERRANEAN REGION

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Abstract. Red Globe is a table grape variety with commercial importance, preferred in terms of cultivation. This variety is new to our country and the Mediterranean Region. The objective of the present study was to determine phenological periods, fruit quality, cluster properties, berry characteristics, chlorophyll content, photosynthetic rate and nutrient status of 'Red Globe' on 41 B, SO 4, and 1103 P rootstocks. This grape variety ripened during both years in the first week of August. It was determined that effective heat summation (EHS), required from bud burst until ripeness, was 1600-1700 degree days (d.d). SO4 rootstock yielded the highest value in terms of cluster and berry weights, Total Soluble solids (TSS)/acidity, and pH, and it was followed by 1103 P rootstock. The effect of rootstock on chlorophyll content was found to be similar. Likewise, it was identified that the effect of rootstocks on photosynthetic and transpiration rates was not significant. Effects of rootstocks on leaf mineral matter intake were found to be significant in terms of certain elements. P, K, Ca and Mg macro nutrient element contents were found to be higher in 1103 P rootstock than the other two rootstocks. Rootstocks showed similarity in terms of the intake of micronutrient elements (other than Fe).
Keywords: *grapevine, rootstock, fruit quality, chlorophyll, photosynthesis*

Introduction

Table grape exhibits a strong growth throughout the world. In the recent years, China and Turkey have shown an increasing trend affected by different dynamics (Seccia et al., 2015). According to 2018 data, Turkey ranks the 2nd in table grape production with 7% (1.9 mt) (OIV, 2019).

The Mediterranean region has an important place in Turkish viticulture in terms of area and production. Table grapes occupy 76.8% of the production under grape cultivation in this region (TUIK, 2019).

Red Globe is a variety appreciated by consumers due to its characteristics as a table grape, which has a potential for increased cultivation in vineyards in terms of producer preferences. As a matter of fact, Red Globe grape variety, cultivated in an area of 165.000 ha, is the second most commonly cultivated table grape variety worldwide (OIV, 2017).

Phylloxera, which is a root-feeding aphid, can kill grapevines of the species *Vitis vinifera* (Cousins, 2005). There is no way to eradicate phylloxera from an infested vineyard. The only sure way to prevent phylloxera damage to grapevines is to plant vines grafted to phylloxera-tolerant rootstocks of American origin (Skinkis et al., 2009; Gautier et al., 2020). Rootstocks have recently gained great importance in the only consistently effective and successful strategy in major viticultural countries worldwide (Rizk-Alla et al., 2011). Grapevine rootstocks can significantly affect the performance of grafted vines (Sivilotti et al., 2007; Li et al., 2019). For this reason, rootstock selection is a critical decision when establishing a vineyard (Jogaiah et al., 2013).

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Grapevine rootstocks are known to affect various aspects of scion performance, such as growth (Satisha et al., 2010; Rizk-Alla et al., 2011; Ibacache et al., 2016), nutrient uptake (Ibacache and Sierra, 2009; Wooldridge et al., 2010; Ibacache et al., 2020), quality (Valenzuela-Ruiz et al., 2005; Satisha et al., 2010; Ghule et al., 2021), and some physiological and biochemical parameters (Koblet et al., 1995; Cox et al., 2012; Jogaiah et al., 2013; Ghule et al., 2021). A rootstock, found to be beneficial for one cultivar, may not be universally advantageous for others, as the interaction of stock and scion influences the vine performance more than the stock or scion alone (Satisha et al., 2010). Any commercial grape cultivar must be cultivated as composite plants by grafting it onto the recommended rootstock (Verma et al., 2010). In viticulture, it is possible to come across many studies (Gu, 2003; Valenzuela-Ruiz et al., 2005; Ibacache and Sierra, 2009; Rizk-Alla et al., 2011; Corso et al., 2016; Klimek et al., 2022) about the appropriate rootstock selection for grape varieties. In the Eastern Mediterranean region, there are a limited number of studies conducted in this regard. In the regional grape trade, it is common to grow Horoz Karası, Hatun Parmağı and Pafı varieties on the rootstock of Rupestris du lot with the goblet training system.

This study used three rootstocks with different genetic characteristics, which are commonly used in Turkey. The aim of this investigation was evaluating the effects of 41 B, 1103 P and SO4 on fruit quality, photosynthesis, chlorophyll content and nutrient status of 'Red Globe' cultivar.

Material and Methods

This study was conducted in the Hatay Mustafa Kemal University, Agriculture Faculty in Turkey, during two consecutive seasons. Study parcel is located at 81 m elevation at 36°18'32"N and 36°13'60"E coordinates in Amik plain in Hatay province, which has a Mediterranean climate. Soil texture is loamy (51% sand, 32% silt and %17 clay), with a pH of 7.97 and an electrical conductivity of 0.78 mmhos/cm. Temperature and precipitation long-term average of Hatay are shown in *Figure 1*. Average temperature was 18.3°C, temperatures in the coldest month were 8.1°C, temperatures in the hottest month were 27.9°C, and average amounts of precipitation were 1161.5 mm by annual.

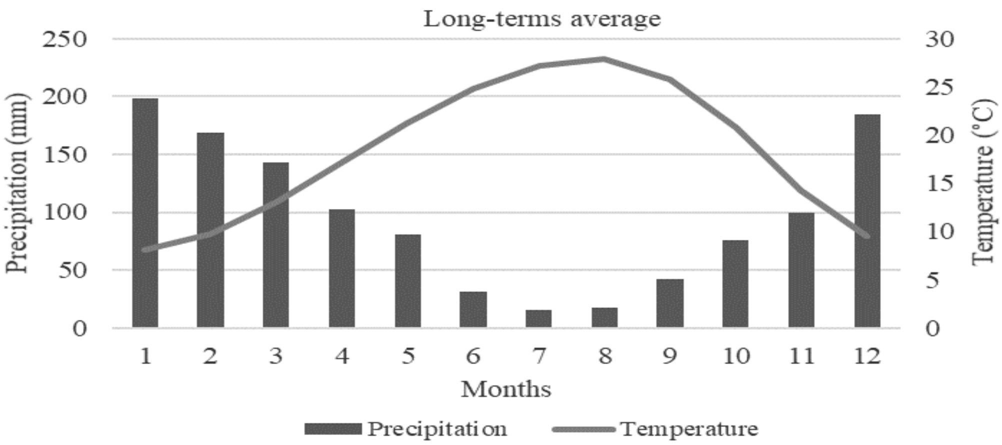

***Figure 1.** Monthly precipitation and average temperature change over long-terms*Hatay meteorology general directorate (Anonymous, 2022)*

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In the trial area, ungrafted rootstock (41B, SO4, 1103P) saplings were planted in a completely randomized block design, in three rows at a spacing of 3.0 m x 2.0 m (row x vine). Each row had 27 vines consisting of 9 on each of three rootstocks. 'Red Globe' cultivar was grafted on rootstocks by cleft grafting method. The 4-year-old vines were trellised by one-armed pergolas system and irrigated by drip irrigation system. Rows were planted in an East-West orientation. Pests and diseases control and other vineyard management practices were applied in accordance with conventional vineyard practice (*Figure 2*).

Figure 2. *A photograph of the research area, infloresence and maturity time*

In the trial, 4 vines were selected and marked for each repetition. Phenological variables, such as determination of bud-break, full bloom, veraison and ripening were collected from each grapevine (Ağaoğlu, 2002; OIV, 2009). In consideration of phenological development dates, EHS (dd) by periods was determined with the following formula as follows (*Eq. 1*) (Winkler et al., 1974).

$$EHS = \sum(T1 - T2) \quad \text{(Eq.1)}$$

where T_1= Daily average temperature (°C), T_2= Equal temperature (10°C).

20 berry samples were picked up in three-day intervals, 5 periods, and each repetition during the period before harvesting in both years of the study with the aim of observing the effect of rootstocks on the progress of ripeness of grapes. TSS, pH, acidity, and ripeness index were analyzed in obtained grape samples. Harvest was made on August 5 in the first year and on August 1 in the second year. Pomological variables in fruits [cluster weight (g), cluster length (cm), cluster width (cm), berry weight (g), berry length (mm), berry width (mm), TSS (%), pH, acidity (%) and TSS/acidity] were measured in the study. Cluster characteristics were identified using 20 clusters during each repeat. 50 berries were used during each repeat for berry characteristics and must properties. TSS content (%) in the juice was determined using hand refractometer (Atago, Manual, made in Japon) and juice pH was determined by pH meter (pH330

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WTW, made in Germany). Acidity was measured using potentiometric method, while prepared juice was titrated with 0.1 N NaOH solution until 8.1 value was read on the pH meter and results were calculated in percentage of tartaric acid. SUNDOO SH-100 Model Digital Force Gauge device was used for measurement berry removal force (N).

Physiological measurements, recently fully expanded two leaves, which were selected randomly from every vine stock, were marked. 8 leaves were used for the measurements of photosynthesis and chlorophyll during each repetition. Photosynthetic rate (μmolm^{-2}s^{-1}) and transpiration rate (mmolm^{-2}s^{-1}) of the leaves were measured, from 09.00 am to 13.00 pm, using a portable photosynthesis system (model LCA-4, ADC Bioscientific Ltd., Hoddesdon, UK). Chlorophyll content (measured SPAD value) was identified on the same leaves using a portable chlorophyll meter (SPAD 502, Minolta Co. Ltd. Japan). In chlorophyll measurements, three readings were made in different directions of each leaf. Additionally, the same leaves were also used for the determination of leaf area and the chlorophyll contents (Chlorophyll a, Chlorophyll b, total Chlorophyll), under laboratory conditions. Chlorophyll was extracted with 80% acetone from leaf discs. Chlorophyll a and chlorophyll b contents, and total chlorophyll content, were measured according to the method of Arnon (1949). Measurements were conducted on May 24 in the first year, and May 18 in the second year.

When the plants were in full bloom, the leaves across the first cluster of primary shoots, which were selected randomly, were collected, and brought to the laboratory in an icebox. 20 leaf blades, collected for each repetition, were washed and dried in the drying oven (65-70°C). Samples, ground in porcelain mortars, were burned in muffle furnace according to dry ashing method. N content was determined according to Kjeldahl method. Total P, K, Ca, Mg, Mn, Fe, Cu ve Zn concentrations of dissolved samples were determined by ICP-OES (Kacar and İnal, 2008). Macro elements were determined as %, and micro elements were determined as ppm.

Statistical analysis

The data was analyzed as a completely randomized block design by the analysis of variance using SAS software. The mean separations were carried out by the least significant difference (LSD) method at a 5% significance level.

Results and Discussion

In Red Globe grape variety, effects of different rootstocks on phenological periods were found to be similar on the basis of years. Upon analysis of monthly average temperature values by years, it was determined that the values for the second year were higher than the first year (*Table 1*); thus, full bloom occurred 9-10 days, veraison occurred 7-8 days and ripening occurred 4 days earlier (*Table 2*). As a matter of fact, according to Winkler index method; EHS during both bud break-harvest and flowering-harvest times were higher in the second year (*Table 3*). Steel and Greer (2008) also reported in their study with the same variety that they did not observe difference in phenological stages (bud break, flowering, and harvest time) between rootstocks. Similarly, it was observed that rootstocks were not effective on phenological periods in Red Globe variety grafted on Harmony and Freedom rootstocks (Valenzuela-Ruiz et al., 2005). Santibáñez et al. (2014) reported that EHS (dd) requirements of late season cultivars such as Red Globe and Crimson Seedless, to complete fruit maturity from full flower, were 1100 to 1500 dd. In the study, EHS requirement in Red Globe variety

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(1268.2-1371.7) was found to be between limit values indicated by the researchers. In other studies; EHS (full flower- maturity) value of the same cultivar was determined as 1133.0 dd in Sakarya (Cangi and Altun, 2015) and 1447.0 dd in Antalya (Aktürk and Uzun, 2019). In ecologies, the period from bud break until ripeness is systematically reduced due to increased temperature. In other terms, ripeness can be achieved 1 to 2 months earlier in hotter regions than colder regions (Santibáñez et al., 2014). In this study conducted within Mediterranean ecology, the period between flowering and harvest were determined as 79 to 85 days.

Table 1. *Monthly precipitation and average temperature change by years**

Year	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1st	Temp. (ºC)	8.1	9.2	12.2	16.0	20.5	25.2	28.0	28.8	26.2	18.7	9.4	6.6
	Pcpn.(mm)	70.4	75.8	56.8	53.4	26.2	11.4	0.0	0.0	0.6	63.5	42.8	132.8
2nd	Temp. (ºC)	6.7	8.2	12.2	18.1	21.5	26.8	28.9	29.6	27	20.2	14.6	9.4
	Pcpn.(mm)	279.7	0.0	19.6	24.3	30.8	2.0	0.0	0.0	0.0	61.2	158	280.5

*Hatay Meydan meteorology station

Table 2. *The effects of rootstocks on phenological development dates (days.month) for Red Globe grapes grown in the East Mediterranean region*

Rootstock	Bud break		Full bloom		Veraison		Ripening	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
41B	03.04	03.04	19.05	10.05	20.07	12.07	05.08	01.08
SO4	04.04	04.04	20.05	10.05	20.07	12.07	05.08	01.08
1103P	03.04	04.04	20.05	10.05	19.07	12.07	05.08	01.08

Table 3. *The values of EHS according to phenological periods*

Fenological Stages	Heat summation above 10 °C (degree days/total days)	
	1st year	2nd year
Bud burst-Full bloom	334.1/46 days	329.4/37 days
Full bloom- Veraison	966.9/63 days	979.6/64 days
Veraison- Ripening	301.3/16 days	392.1/20 days
Bud burst-Ripening	1602.3/125 days	1701.1/121 days

In non-climacteric fruits likes grape, TSS and acidity play on major role at the time of maturity (Chanana and Gill, 2008). Therefore, TSS, pH, acidity and TSS/acidity changes in berries, collected periodically during the period close to ripeness in Red Globe variety, were analyzed in the study (*Figure 3*). In general, the highest proportional increase in the ripeness index was observed in SO4 rootstock. This increase was determined as 109% in the first year and 145% in the second year according to approximately 11-12 days before harvest. During this period, TSS % content increased and acidity % content decreased. Miele and Rizzon (2019) also reported that there was an inverse relationship between these two characteristics during

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the ripening of grapes. Muñoz-Robredo et al. (2011) determined that Red Globe variety showed a continuous rise in TSS throughout the sampling period, a decrease in titratable acidity during berry development, and an increase in TSS/acidity quotient toward harvest. Segade et al. (2013) reported that similar results were obtained in the same variety at different stages of ripeness.

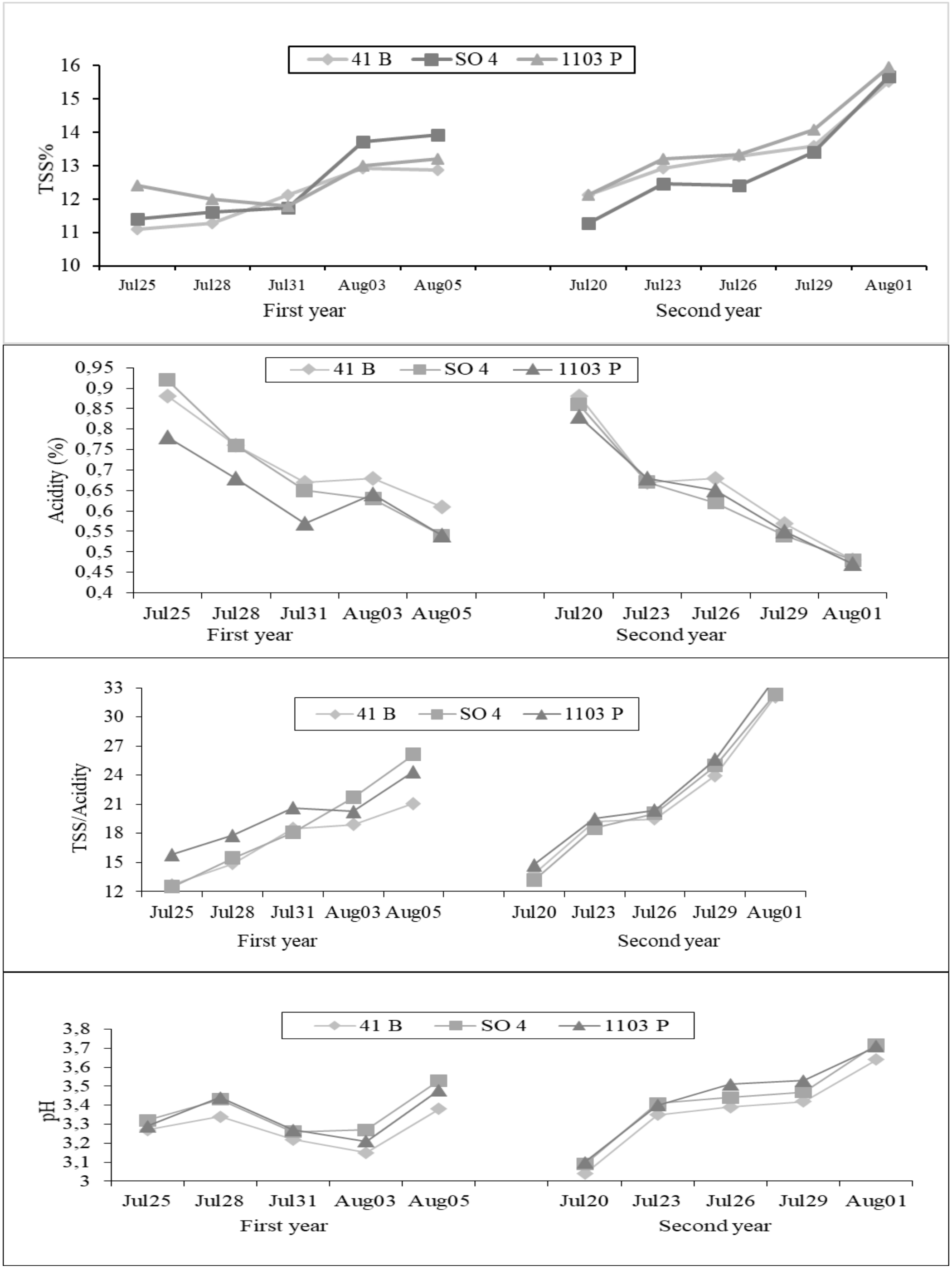

Figure 3. *TSS, acidity, TSS/acidity and pH changes by years in the ripeness progress of Red Globe variety*

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Table 4 indicates the effect of rootstocks on juice quality of Red Globe variety at the time of harvest. In terms of the first year, the second year, and the average for both years, the effect of rootstocks on TSS content was not found to be significant. While the effect of rootstocks on pH, acidity, TSS/acidity content was found to be significant in the first year, it was not significant in the second year. In terms of the average for both years SO4 rootstock, which gave the highest statistical value in pH and TSS/acid content, was followed by 1103 P rootstock (*Table 4*). Rizk-Alla et al. (2011) found the performance of Red Globe variety on its own root and 5 rootstocks to be significant in terms of TSS, acidity and TSS/acid ratio. In certain other studies, it was reported by Sivilotti et al. (2007) and Cus (2004) that no significant difference was found in terms of these characteristics between, respectively, 7 rootstocks (SO4, 420A, 3309C, 161-49C, Fercal, 1103P, 5BB) and 3 rootstocks (SO4, 1103P and 420A). Furthermore, vegetation period can also affect the differences between rootstocks in term of quality (Sivilotti et al., 2007).

Table 4. *The effects of some rootstocks on juice composition of 'Red Globe' table grapes in the East Mediterranean region*

Rootstock	TSS (%)			pH			Acidity (%)			TSS/acidity		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
41 B	12.87	15.53	14.20	3.38 b*	3.64	3.51 b	0.61 a	0.48	0.55	21.07 b	32.09	26.58 b
SO4	13.93	15.67	14.80	3.53 a	3.72	3.63 a	0.54 b	0.48	0.51	26.11 a	32.33	29.22 a
1103P	13.20	15.97	14.58	3.48 a	3.71	3.59 ab	0.54 b	0.47	0.51	24.37 ab	33.98	29.17 ab
LSD(*P*=0.05)	ns	ns	ns	**	ns	**	**	ns	ns	**	ns	**

*:Values not associated with the same letter(s) are significantly different; **: Significant at 0.05 level; ns: Not significant

Rootstocks affected some cluster properties and berry properties (Kaplan et al., 2018). Cluster weight differed significantly among the rootstocks. The greatest cluster weight was given by SO4 rootstock, while the smallest cluster weight was recorded on 41B and 1103P rootstocks (*Table 5*). Vines grafted on 41B rootstock yielded a cluster width value lower than SO4 and 1103P rootstocks. The effects of rootstocks on average cluster length (26.17-27.44 cm) are similar in the study. However, it may be suggested to shorten the cluster length for satisfying packaging and marketing needs. This operation called berry thinning is removed with one-third of the bottom part of the cluster. Berry thinning is performed when berries are at pea-size, in order to give more uniform clusters in terms of weight and shape (Zabadal, 2002; Di Lorenzo et al., 2011).

The berry weight is an important aspect in quality grape production which was significantly influenced by the use of different rootstocks (Ghule et al., 2021). In the study, the effects of rootstocks on berry weight and berry width were found to be significant in the first year, while their effects on berry length were found to be significant in both years. According to the values for the average of both years, SO4 and 1103 P rootstocks yielded higher values than 41 B rootstock (*Table 6*).

Rizk-Alla et al. (2011) determined that rootstocks significantly affected berry physical components in Red Globe variety cultivated on its own root and Dogridge, Salt Creek, Freedom, Harmony, 1103P. In another study, where the same variety was cultivated on its own root and Freedom, Salt Creek, 110R, rootstocks also had a significant effect on berry weight and size (Hifny et al., 2016). Also in another study, it

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was reported that berry weight and berry diameter of Red Globe cultivar were significantly affected by the use of different rootstocks (Ghule et al., 2021).

Table 5. *The effects of some rootstocks on cluster properties of ‘Red Globe’ table grapes in the East Mediterranean region*

Rootstock	Cluster weight (g)			Cluster width (cm)			Cluster length (cm)		
	1styear	2ndyear	Mean	1styear	2ndyear	Mean	1styear	2ndyear	Mean
41 B	915.19 c*	826.86 b	871.02 b	15.10 b	13.55 b	14.33 b	27.66	24.68	26.17
SO4	1105.75 a	927.84 a	1016.80a	16.38 a	14.60 a	15.49 a	28.77	26.10	27.44
1103P	1012.90 b	913.32 ab	963.11 b	15.79 ab	14.48 a	15.13 a	29.04	25.45	27.25
LSD(*P*=0.05)	**	**	**	**	**	**	ns	ns	ns

*:Values not associated with the same letter(s) are significantly different; **: Significant at 0.05 level; ns: Not significant

Table 6. *The effects of some rootstocks on berry properties of ‘Red Globe’ table grapes in the East Mediterranean region*

Rootstock	Berry weight (g)			Berry width (mm)			Berry length (mm)			Berry removal force (N)		
	1styear	2ndyear	Mean	1styear	2ndyear	Mean	1styear	2ndyear	Mean	1styear	2ndyear	Mean
41B	10.37 b*	9.54	9.96 b	23.93 b	24.26	24.10 b	26.87 b	25.52 b	26.20 b	9.18	6.28	7.73
SO4	11.80 a	10.25	11.02 a	25.12 a	24.68	24.90 a	28.01 a	26.32 a	27.17 a	8.59	6.48	7.54
1103P	11.29 a	9.95	10.62 a	24.31 b	24.53	24.42 ab	28.09 a	26.31 a	27.20 a	8.92	6.16	7.54
LSD(*P*=0.05)	**	ns	**	**	ns	**	**	**	**	ns	ns	ns

*:Values not associated with the same letter(s) are significantly different; **: Significant at 0.05 level; ns: Not significant

In terms of berry physical components, berry removal force was found to be between 7.54-7.74 N in rootstocks according to the average values for both years. Kamiloglu and Demirkeser (2019) determined that berry removal force was 7.30 N in Red Globe variety grafted on 1103 P; while Segade et al. (2013) determined that berry removal force of the same variety grafted on 140 Ru rootstock varied between 4.90 and 7.66 N according to ripeness periods.

In the study, the effects of rootstocks on leaf chlorophyll (chlorophyll a, chlorophyll b, total chlorophyll, and SPAD) contents of Red Globe grape were found to be similar (*Table 7*). Kuljančić et al. (2012) determined the photosynthesis ratio as 6.9 µmol $m^{-2}s^{-1}$, and transpiration ratio as 2.4 mmol $m^{-2}s^{-1}$ in leaves on the main shoot in Sila grape cultivar. These results were found within the range of values obtained in our study. However, there was no statistical difference between rootstocks in terms of these physiological characteristics (photosynthesis ratio and transpiration ratio) (*Table 8*). Although Bica et al. (2000) suggested that rootstocks could have a significant effect on photosynthetic parameters, their study that photosynthesis ratio was similar in Pinot Noir plants grafted on SO4 and 1103P rootstocks. Somkuwar et al. (2015), associating high photosynthesis ratio with leaf area and shoot length, reported that 110 R, which had the highest photosynthesis ratio in their study, could have gained maximum benefit from sunlight due to the increase in leaf area.

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Table 7. *The effects of rootstocks on chlorophyll content and leaf area for Red Globe grapes grown in the East Mediterranean region*

Rootstock	Chlorophyll ‘a’ (mg g $^{-1}$ FW)			Chlorophyll ‘b’ (mg g $^{-1}$ FW)			Total Chlorophyll (mg g $^{-1}$ FW)			SPAD			Leaf area (cm^2)		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
41 B	0.71	0.90	0.80	0.30	0.41	0.35	1.15	1.52	1.33	29.59	30.40	30.00	177.33	204.13	190.73
SO4	0.72	0.92	0.82	0.29	0.38	0.34	1.16	1.52	1.34	30.11	31.68	30.90	170.54	200.38	185.46
1103P	0.84	0.91	0.87	0.29	0.37	0.33	1.31	1.51	1.41	29.35	31.18	30.26	162.96	199.67	181.31
LSD(P=0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

FW: Fresh weight, ns: Not significant

Table 8. *The effects of rootstocks on photosynthetic rate, transpiration rate for Red Globe grapes grown in the East Mediterranean region*

Rootstock	Photosynthetic rate (µmol m^{-2} s^{-1})			Transpiration rate (mmol m^{-2} s^{-1})		
	1st year	2nd year	Mean	1st year	2nd year	Mean
41 B	6.13	5.16	5.65	2.12	2.69	2.40
SO4	7.40	5.43	6.42	2.10	2.90	2.50
1103P	6.51	4.91	5.71	1.94	2.61	2.28
LSD(P=0.05)	ns	ns	ns	ns	ns	ns

ns: Not significant

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The use of rootstocks can have an important effect on the mineral nutrition of the grafted variety. Little is known about the specific mechanisms used by grape rootstocks to absorb nutrients (Ibacache and Sierra, 2009). Many reports dealt with mineral uptake and distribution of minerals in grapevine; it was noticed that the differences in nutrient uptake and distribution could be attributed to the genotype of rootstock which gives a different absorption capability or tendency for some specific minerals (Rizk Alla et al., 2011). The effects of rootstocks on macro nutrient uptake in Red Globe grape variety were given in *Table 9*. No significant differences were observed in leaf N content among the rootstocks. Similar effects were observed by Dalbo et al. (2011) and Vijaya and Srinivas Rao (2015) when using different rootstocks. However, the effects of rootstocks on P, K, Ca and Mg absorption were statistically significant. It was determined that the effect of 1103 P on the uptake of these elements was higher than other rootstocks. As a matter of fact, Jogaiah et al. (2013) reported that rootstocks with a *Berlandieri x Rupestris* genetic background generally have a good ability for nutrient uptake. Ibacache and Sierra (2009) reported that the effects of Red Globe grape variety, grafted on 10 different American vine stocks, on N (0.86-1.29%), P (0.21-0.42%), K (1.47-3.37%) uptake in leaf petioles were significant; while the effect of Salt Creek rootstock on P uptake and the effect of Harmony rootstock on K uptake were higher than the others. Risk-Alla et al. (2011) found in their study, where they analyzed the leaf mineral content of the same variety on 5 different rootstocks, that the most effective rootstocks were, respectively, Dogridge and Salt Creek on N (0.63-0.72% and P (0.32-0.37%) uptake, and Freedom on K (0.40-0.44%) uptake. In our study, the N content in Red Globe leaves was found between 2.67-2.86% in the first year and 2.52-2.78% in the second year. it was seen that these values were close to the limit values (2.30-2.80%) reported by Bergman (1992). While P content was within the range of limit value (0.25-0.45%) in 1103P and SO4 rootstocks, it was partially low in 41 B rootstock. Weaver (1976) categorized K content values between 0.8% and 1.5% as close to normal level, and above 1.5% as adequate. In our study, rootstocks did not adequately affect K uptake. The lowest K content was determined in 41 B rootstock. At the same time, Ca content was found to be below the limit value (1.5-2.5%) in this rootstock.

Table 9. *The effects of rootstocks some macro element concentrations for Red Globe grapes grown in the East Mediterranean region*

Rootstock	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
41B	2.86	2.52	2.69	0.23b*	0.23 c	0.23 c	0.82	0.76 b	0.79b	1.18	1.48 b	1.33b	0.24	0.30 ab	0.27b
SO4	2.67	2.78	2.72	0.26 b	0.30 b	0.28b	0.79	0.87a	0.83ab	1.34	1.82 a	1.58ab	0.23	0.29 b	0.26b
1103P	2.72	2.56	2.64	0.38 a	0.35 a	0.37 a	0.91	0.84 a	0.87 a	1.50	1.78 ab	1.64 a	0.27	0.35 a	0.31 a
LSD (*P*=0.05)	ns	ns	ns	**	**	**	ns	**	**	ns	**	**	ns	**	**

*:Values not associated with the same letter(s) are significantly different; **: Significant at 0.05 level; ns: Not significant

Differences between rooting models of different rootstocks may affect water and nutrient uptake (Somkuwar et al., 2008). There are very few studies on the effect of

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rootstocks on microelement uptake (Vijaya and Srinivas Rao, 2015). In this study, micronutrient element contents in Red Globe leaves were given in *Table 10*.

Table 10. *The effects of rootstocks some micro element concentrations for Red Globe grapes grown in the East Mediterranean region*

Rootstock	Mn (ppm)			Fe (ppm)		
	1st year	2nd year	Mean	1st year	2nd year	Mean
41 B	21.54	31.17	26.36	80.68	124.39 ab	102.53
SO4	21.16	38.68	29.92	74.65	135.96 a	105.30
1103P	22.02	29.48	25.75	80.65	112.40 b	96.52
LSD(*P*=0.05)	ns	ns	ns	ns	**	ns
Rootstock	**Cu (ppm)**			**Zn (ppm)**		
	1st year	2nd year	Mean	1st year	2nd year	Mean
41 B	24.54	8.18	16.36	41.66	16.64	29.15
SO4	19.98	11.11	15.54	41.19	15.06	28.13
1103P	19.66	7.64	13.65	37.88	18.00	27.94
LSD(*P*=0.05)	ns	ns	ns	ns	ns	ns

**: Significant at 0.05 level; ns: Not significant

The effects of rootstocks on Mn, Fe (except for 2nd year), Cu, Zn uptake were not found to be statistically significant. Dalbo et al. (2011) reported in their study that micronutrient accumulation in petioles was not affected by rootstock. According to Gärtel (1993), Mn and Fe contents in Red Globe leaves displayed slight deficiency in the 1st year and they were at an optimal level in the 2nd year of the study, while Cu was at an optimal level in both years. Zn content was found to be higher and at an optimal level in the 1st year (in comparison with the 2nd year).

Conclusion

In modern viticulture, grafting commercial grapevine varieties on interspecific rootstocks is a common practice required for conferring resistance to many biotic and abiotic stresses. Nevertheless, the use of rootstocks is also known to impact grape berry development and quality (Corso et al., 2016).

In the study, no difference was observed in terms of the effects of rootstocks on phenological periods in Red Globe variety. It ripened during the first week of August in Mediterranean ecological conditions, and EHS of bud burst-ripeness period was found to be 1600-1700 dd. The highest value in terms of cluster and berry weights and ripeness index were yielded by SO4 rootstock, which was followed by 1103 P rootstock. According to the averages for two years, it was determined that rootstocks did not have any effect on accumulation of micronutrient elements, while 1103 P yielded higher values than other two rootstocks in terms of macronutrient elements (P, K, Ca, Mg). The effects of rootstocks on chlorophyll a, chlorophyll b and total chlorophyll contents were found to be similar. No significant difference was observed between rootstocks in physiological measurements such as photosynthesis and transpiration ratio.

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