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ORIGINAL ARTICLE

Effects of Substrate and Crop Load On Yield and Mineral Nutrition of 'Early Sweet' Grape Cultivar Grown in Soilless Culture

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Abstract
The study was conducted to determine optimum substrate type and crop load in soilless grape culture. 'Early Sweet' table grapes were used as the plant material. Grapevines were grown under plastic cover with nutrient solutions. Three different substrates (Cocopeat, mixture of Perlite and Peat (2:1, v:v) and Basaltic Pumice) and two different level of crop loads (10 and 15 clusters per grapevine) were experimented. To determine the effects of applications, in the first year, some shoot parameters and in the second year, grape yield, cluster, berry and must characteristics and leaf nutrients were examined. The highest grape yield (38 t ha^{-1}) was obtained from Perlite:Peat medium and 15-cluster crop load treatment. Average cluster weights varied between 263.87 g (Cocopeat) and 346.18 g (Perlite:Peat). For all treatments, nitrogen, phosphorus, potassium, calcium, iron and zinc concentrations of the leaves sampled at veraison were lower but, magnesium concentrations were higher than the optimum limits reported the previous literature.
So, sufficient yield and quality levels were achieved, Perlite:Peat medium and 15 clusters $vine^{-1}$ crop load treatments were recommended for 'Early Sweet' cultivar to cultivate in soilless culture under plastic house. However, because it was a locally available and cheap material, Basaltic Pumice with close yield levels to the other growth media was also recommended for soilless grape culture.

Keywords Crop load · Grapevine · Nutrient · Protected cultivation · Soilless culture · Substrate

Auswirkungen von Substrat und Fruchtbehang auf Ertrag und Mineralstoff-Versorgung der Rebsorte 'Early Sweet'

Schlüsselwörter Fruchtbehang · Weinrebe · Nährstoff · Geschützter Anbau · Anbau außerhalb des gewachsenen Bodens · Substrat

Introduction

Protected cultivation of table grapes was initiated in Mediterranean region in 90s. This region has gained importance especially in terms of its earliness characteristics. 'Yalova Incisi', 'Trakya Ilkeren', 'Early Cardinal' and 'Ergin Seedless' are some of the grape cultivars already cultivated in Mediterranean region (Uzun 1993; Uzun and Özbaş 1995; Tangolar and Paydaş 2011; Tangolar 2016). These early maturing varieties have been sold at high price, and provide high income to the grape grower. On the other hand, it is seen that 'Prima', 'Early Sweet' and 'Black Magic' varieties have also been recently brought profit to the producers. In Mediterranean region, early cultivars are usually harvested in the first week of June when they were grown in open fields and in the middle or end of May when they were grown under plastic or glasshouse without heating (Uzun and Özbaş 1995; Ergenoğlu et al. 1999; Kamiloğlu et al. 2011; Tangolar and Paydaş 2011).

Although soilless culture systems were initially developed for vegetables (Gül 2012) and ornamental plants, Di Lorenzo and Mafrica in 2000 (Di Lorenzo and Mafrica

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2000) and Di Lorenzo et al. in 2009 and 2012 (Di Lorenzo et al. 2009, 2012), grew table grapes using soilless culture and reported yield levels of over 40 tons per hectare. Buttaro et al. (2012) also carried out a study in Italy and indicated that quality grapes compatible with international market standards could be produced in soilless culture.

Due to the most favorable ecological conditions and well-established history of viticulture and greenhouse production, Turkey has a great advantage for under-cover grape culture over the other world countries. But, it's quite late in using such a great potential. In soilless grape culture studies, which can be considered as new in Turkey, it is very important to determine the most suitable organic and inorganic substrates, mixtures, composition of nutrient solutions. One of the important basic issues that directly affect yield and quality of table grapes grown in open and under cover is also crop load, which is related to the number of buds left in the pruning of the vines, namely the "vine charge" (Çelik 2011; Bowen et al. 2011; Terry and Kurtural 2011). The level of vine charge alters canopy size, shoot development, and fruit cluster numbers per vine (Kurtural et al. 2013; Wessner and Kurtural 2013; Rahmani et al. 2015). Especially, leaving too many buds in excess in order to obtain high yields often results in insufficient leaf area for excess grape yield. There are a few studies related with soilless grape culture in Turkey. Polat et al. (2003) carried out a study in Antalya with 'Trakya İlkeren' grape cultivar and different pot sizes and pointed out soilless grape culture potential of the province. Sabır et al. (2012) studied on development of some grape cultivars in soilless culture under glasshouse in Konya. Tangolar et al. (2016) investigated the effects of different Nitrogen and Potassium concentrations and the same researchers in year 2017 (Tangolar et al. 2017) searched the effects of two growth media on grape yield and quality of some grape cultivars grown soilless culture conditions in Adana.

In this study, considering different growth media and bud loads, it was aimed to optimize the cultivation of 'Early Sweet' grape variety in the soilless culture system in terms of grape yield and some cluster and berry characteristics and nutrient content of the leaves.

Materials and Methods

Materials

This study was conducted in under-cover soilless culture system at Horticulture Department of Çukurova University Agricultural Faculty in 2015 and 2016. 'Early Sweet' grape cultivar (*Vitis vinifera* L.) was used as plant material of the study.

Growth Media (Substrates)

Basaltic pumice, cocopeat, perlite and peat are the common substrates used as growth media in soilless cultures (Buttaro et al. 2012; Di Lorenzo et al. 2009, 2012; Kasım and Kasım 2004; Gül 2012; Varış et al. 2012). In this present study, Basaltic Pumice and Cocopeat were used alone, while Perlite and Peat were mixed (2:1, Perlite:Peat, in volume).

Nutrient Solution

Modified Hoagland nutrient solution from the previous Hoagland studies (Hoagland and Arnon 1950; Buttaro et al. 2012; Tangolar et al. 2017) was used. Nutrient solution composition was arranged to have 100 mg kg^{-1} nitrogen (N) (in $Ca(NO_3)_2$ form), 20 mg kg^{-1} phosphorus (P) (in H_3PO_4 form), 150 mg kg^{-1} potassium (K) (in KSO_4 or KNO_3 form), 20 mg kg^{-1} magnesium (Mg) (in $MgSO_4$ form), 15 mg kg^{-1} sulphur (S) (in sulphate forms), 5 mg kg^{-1} iron (Fe) (in Fe-EDDHA form), 1 mg kg^{-1} zinc (Zn) (in $ZnSO_4.7H_2O$ form), 3 mg kg^{-1} manganese (Mn) (in $MnSO_4$ form), 0.2 mg kg^{-1} copper (Cu) (in $CuSO_4.5H_2O$ form) 0.4 mg kg^{-1} boron (B) (in H_3BO_3 form) and 0.05 mg kg^{-1} molybdenum (Mo) (in $NH_4Mo_7O_{24}$. $4H_2O$ form).

Methods

Crop Loads

Two different crop loads (10 and 15 clusters per grapevine) were experimented in above specified growth media. For crop load treatments, clusters were counted in each grapevine just before berry set period and cluster thinning was performed as to have two crop load levels.

Nutrient Solution Applications

Application of nutrient solutions were initiated with the burst of buds (1 March 2016) in the second year. Nutrient solution was supplied until maturity (until 4 June 2016) for about 15 weeks as to have 50% more of the macro and micro nutrients applied in the first year. Following the harvest, nutrients were applied at the rates of the first year for 12 weeks.

As recommended by Buttaro et al. (2012), Di Lorenzo et al. (2009, 2012, 2013) and Tangolar et al. (2017), 1–3 L day^{-1} water was applied to each plant between bud-burst and defoliation periods. Tap water with a pH value of 7.86 and EC value of 0.698 was used in irrigation. Plants were irrigated with this tap water maintaining a drainage solution level of about 20% of the total water volume applied.

Table 1 Effects of treatments on shoot length and number of nodes of vines in the first year

Substrate	15 May 2015		18 June 2015	
	Shoot length (cm)	Number of nodes (*n*)	Shoot length (cm)	Number of nodes (*n*)
Cocopeat	29.58 c*	11.08 c	174.08 b	34.50 b
Perlite:Peat	57.88 a	15.25 a	235.67 a	38.67 a
Basaltic Pumice	40.33 b	13.00 b	181.25 b	33.33 b
LSD 5%	7.37	1.61	24.06	2.89
Pr > F	0.0016	0.0122	0.0085	0.0418

NS Non-significant
*Mean separation within columns by LSD multiple range test at 0.05 level

Production Cycle

The First Year (2015): Year of Shoot Obtaining Initially, cuttings in standard specifications with 3–5 buds (Anonymous 1995) were prepared to get the experimental materials. Cuttings were rooted in perlite medium between February–March, only water was supplied when required. Following 1–2 months of rooting period, rooted scions were planted in 32 L pots containing 3 different growth media as of Basaltic Pumice, Cocopeat and Perlite:Peat mixture (2:1, v:v) on 25 March 2015. Following the planting, water and nutrient solutions were supplied until 14 September 2015 for 26 weeks. Nutrient solution was supplied once a week as to supply 500 mg N, 100 mg P, 750 mg K, 111 mg Mg, 5 mg Zn, 2 mg B, 0.1 mg Cu, 15 mg Mn, 0.3 mg Mo and 27.8 mg Fe in pure. Plants were grown for 10 months under open conditions.

The Second Year (2016): Crop Year The plants obtained in the first year were pruned to leave about 1 m shoot length in January right after defoliation. Grapevines were trained a single-armed Guyot system. In the study, 60 cm of this shoot was laid on a wire pulled from a 40 cm height from the ground. In each plant, shoots from 6–7 buds on the wire were taken into consideration.

All pots were transferred to plastic greenhouse and placed at 0.75 m on-row and 1.50 m intra-row spacing. Plastic greenhouse was in 3 m high, 6 m wide and 25 m long. Heating was not performed and cover was placed on 28 January 2016.

To prevent bird damages, all the openings of the greenhouse including the doors were covered with a net of white color and a shade of 15% between veraison and maturity stages.

Investigated Properties

To compare the experimental treatments, in the first year of the experiment; shoot length (cm), number of nodes (*n*), stem diameter (mm), was considered. Values for these properties were taken in a single shoot developed in each plant. In the second year of the experiment; maturity dates, grape yield (g vine^{-1}), cluster weight (g), berry weight (g), berry volume (mL), total soluble solids (TSS) (%), titratable acidity (g 100 mL must^{-1}), pH, maturity index and stem diameter (mm) values were investigated. For cluster, berry and juice characteristics, ten cluster samples and 100 berries taken from each replicate were used.

In the second year of the experiment, to determine the effects of treatments on the level of leaf nutrients, leaf samples were taken from the opposite of the first cluster in veraison (Winkler et al. 1974; Tangolar and Ergenoğlu 1989; Çelik et al. 1998; Çelik 2011). Twenty leaf blades for each replicate were used for mineral analyses. Leaf samples were made ready for analyses in accordance with Torun et al. (2016). About 0.2 g samples were ashed in an oven at 550 °C for 5–6 h. Resultant ash was dissolved in 1/33 HCL and filtered by blue-band filter papers to get extraction solutions. Resultants extracts were subjected to K, Ca, Mg, Mn, Fe and Zn analyses in an atomic absorption spectrophotometer (AAS) device (Analitik Jena, ContrAA700). *P* analyses were performed spectrophotometrically in accordance with Barton (1948) and Leaf N contents were determined with Kjeldahl distillation method (Bremner 1965).

Experimental Design and Statistical Analysis

The study was planned in three replications with two plants in each. In the first year of the experiment, variance analysis was carried out in consideration of one factor (Growing medium). In the second year of experiment, study was arranged and analyzed according to the split plots experimental design. Growth media were placed in main plots and crop loads were placed as sub-plots. Resultant data were subjected to variance analysis using JMP statistical software and means were separated with the least significant difference (LSD) test at 5% significance level.

Table 2 Effects of treatments on stem diameter of vines in year 2015

Substrate	Stem diameter (mm)
Cocopeat	12.08
Perlite:Peat	11.17
Basaltic Pumice	11.45
LSD 5%	NS
Pr>F	0.2804

NS Non-significant

Table 3 Effects of treatments on maturity dates of plants in year 2016

Sources of Variation	Maturity dates (Day/Month)
Substrate	
Cocopeat	04/06
Perlite:Peat	05/06
Basaltic Pumice	07/06
Crop Load	
10 Clusters	04/06
15 Clusters	06/06

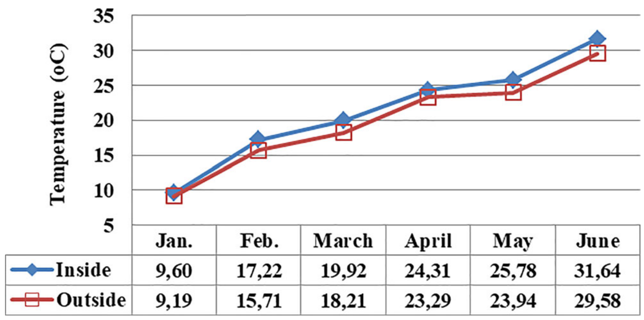

Fig. 1 Changes in temperature values measured inside and outside of plastic house

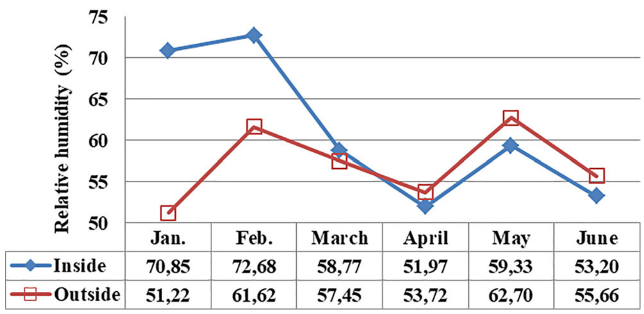

Fig. 2 Changes in mean monthly relative humidity (%) values measured inside and outside of plastic house

Results and Discussion

The First Year Results

The effects of nutrient solution treatments on shoot length of the plants grown in different growth media were determined through measuring shoot lengths and number of nodes at two different dates (15 May and 18 June) in the first year of the experiments. The greatest shoot lengths (57.88 and 235.67 cm at different measurement dates, respectively) were observed in Perlite:Peat medium (Table 1). This growth medium was followed by Basaltic Pumice medium. Average number of nodes was also the highest in Perlite:Peat medium both of the measurement dates (Table 1).

Considering stem diameters, differences were not found to be significant in different growth media (Table 2).

At the last measurement date, values of shoot lengths (between 174.08 and 235.67 cm), number of nodes (between 33.33 and 34.50) and stem diameters (between 11.17 and 12.08 mm) of plants showed that, these shoots were classified as "first-class shoot quality" according to TSE 4027 standard of Turkey (Anonymous 1995) and they were able to be classified as "fertile shoot" (Çelik et al. 1998; Çelik 2011).

The Second Year Results

Yield and Quality Attributes

Monthly mean temperature recorded inside and outside of the plastic house have increased progressively from January (Month of covering) to the June (Month of maturity) and varied from 9.60 to 31.64 °C for inside and from 9.19 to 29.58 °C for outside of plastic house (Fig. 1). In the same period, while the greenhouse relative humidity was high at the beginning, it was found to be lower than outside towards the ripeness (Fig. 2).

According to the average values, maturity was observed on 4 June in Cocopeat medium, on 5 June in Perlite:Peat medium, on 7 June in Basaltic Pumice medium (Table 3). The maturity was observed on 4 June in 10-cluster crop load treatment and on 6 June in 15-cluster crop load treatment. The maturity dates of 4–7 June identified for 'Early Sweet' grape cultivar grown under-cover comply with the maturity date (10 June) of 'Black Magic' and 'Victoria' cultivars indicated by Buttaro et al. (2012) for Perlite:Peat medium in the first year of production season. Buttaro et al. (2012) reported the harvest date of the under-cover culture in the second year as 21 June. Considering the second year of that study, about 11 days earliness was achieved in present study. Such a finding can be considered as a significant outcome of the present study. Similarly, Tangolar et al. (2015)

Table 4 Effects of treatments on yield, cluster and berry characteristics of vines in year 2016

Sources of Variation	Yield (g vine^{-1})	Cluster weight (g)	Berry weight (g 100 berries^{-1})	Berry volume (mL.100 berries^{-1})
Substrate				
Cocopeat	3237 b*	263.87	406.1 a	385 a
Perlite:Peat	4363 a	346.18	356.5 b	340 b
Basaltic Pumice	3609 b	291.07	334.0 b	318 b
LSD 5%	536	NS	31.96	31
Pr>F	0.0621	0.0951	0.0205	0.0250
Crop Load				
10 Clusters	3077 b	307.70	369.6	353
15 Clusters	4396 a	293.05	361.5	343
LSD 5%	658	NS	NS	NS
Pr>F	0.0053	0.5883	0.6113	0.5108
Interaction				
LSD 5%	NS	NS	NS	NS
Pr>F	0.2551	0.4919	0.4291	0.4909

NS Non-significant
*Mean separation within columns by LSD multiple range test at 0.05 level

Table 5 Effects of treatments on must characteristics of vines in year 2016

Sources of Variation	TSS (%)	Acidity (g 100 mL^{-1})	pH	Maturity Index
Substrate				
Cocopeat	14.0 a*	0.469	3.70	29.9 a
Perlite:Peat	13.0 b	0.454	3.67	28.7 a
Basaltic Pumice	12.4 b	0.502	3.64	24.7 b
LSD 5%	0.7	NS	NS	2.3
Pr>F	0.0199	0.1921	0.2414	0.0204
Crop Load				
10 Clusters	13.4	0.489	3.66	27.7
15 Clusters	12.8	0.461	3.68	27.8
LSD 5%	NS	NS	NS	NS
Pr>F	0.1058	0.1893	0.3256	0.9421
Interaction				
LSD 5%	NS	NS	NS	NS
Pr>F	0.7728	0.3653	0.4049	0.5991

NS Non-significant
*Mean separation within columns by LSD multiple range test at 0.05 level

reported 8–16 days earliness for 'Early Cardinal' cultivar, 6–14 days earliness for 'Yalova İncisi' and 8–14 days earliness for 'Ergin Seedless' cultivars in under-cover culture as compared to open field culture. Ergenoğlu et al. (1999) in a study carried out under Adana conditions, reported 15–18 days earliness for the grapevines grown under-cover. All these findings support the present earliness values. Besides these, Kamiloğlu et al. (2011) under Hatay conditions and Uzun and Özbaş (1995) under Antalya conditions also reported close values to our values obtained for earliness.

The highest yield was obtained from Perlite:Peat medium with 4363 g vine^{-1} (3874 kg da^{-1}). The yield was measured as 3237 g vine^{-1} (2874 kg da^{-1}) in Cocopeat medium and as 3609 g vine^{-1} (3205 kg da^{-1}) in Basaltic Pumice medium which were placed in the same statistical group. The yield in 10 and 15-clusters crop load treatments were respectively measured as 3077 and 4396 g vine^{-1}. The effects of growth media and crop loads on cluster weights were not found to be significant. Cluster weights varied between 263.87 g (Cocopeat) and 346.18 g (Perlite:Peat). The highest 100 berry weight and berry volume (respectively as 406.1 g and 385 mL) was observed in Cocopeat medium (Table 4).

Expressed these yield values were about 3–4 times of the yields obtained from open field cultures of Turkey

Table 6 Effects of treatments on mineral element content of the leaves in year 2016

Sources of Variation	Macro elements (%)					Micro elements (mg kg^{-1})		
	N	P	K	Ca	Mg	Mn	Fe	Zn
Substrate								
Cocopeat	2.02*	0.17	0.67 a	1.35 c	0.60	59.32 b	42.31 c	7.29
Perlite:Peat	2.38	0.17	0.66 a	1.72 b	0.61	88.39 a	51.12 b	7.39
Basaltic Pumice	1.91	0.16	0.50 b	1.99 a	0.66	61.83 b	58.05 a	8.79
LSD 5%	NS	NS	0.56	0.24	NS	13.60	5.60	NS
Pr > F	0.4665	0.2895	0.0030	0.0113	0.3290	0.0183	0.0082	0.4118
Crop Load								
10 Clusters	2.09	0.17	0.59	1.63	0.63	70.82	52.11	8.43
15 Clusters	2.12	0.16	0.63	1.75	0.61	68.87	48.89	7.21
LSD 5%	NS	NS	NS	NS	NS	NS	NS	NS
Pr > F	0.9420	0.2686	0.1454	0.3384	0.6533	0.7714	0.2685	0.2488
Interaction								
LSD 5%	NS	NS	NS	NS	NS	NS	NS	NS
Pr > F	0.2101	0.2749	0.2333	0.4829	0.3053	0.1207	0.2070	0.9313

NS Non-significant
*Mean separation within columns by LSD multiple range test at 0.05 level

(900–1000 kg da^{-1}) (Söylemezoğlu et al. 2015). Present cluster weights were classified under "medium-size" group (Anonymous 1997; Çelik 2011). According to TS-101 table grape standards of Turkey, present cluster weights were classified in "extra" group for Perlite:Peat medium and in "Class 1" group for Cocopeat and Basaltic Pumice media (Anonymous 2004). Di Lorenzo et al. (2013) indicated for under-cover culture that quite high yield levels could be achieved (60–70 ton ha^{-1}) in a growing season with the harvest made at two different periods of the same year (respectively in June and October) and these products could be sold at high prices. Buttaro et al. (2012) investigated the effects of different treatments on yields of three different grape cultivars grown under-cover in Perlite:Peat (2:1) growth medium of soilless culture at two different locations and reported the yield as 21.7 t ha^{-1} in the first location and as 29 t ha^{-1} in the second location. In present study, 39 t ha^{-1} yield was obtained from under-cover Perlite:Peat medium with a single harvest. These findings revealed that sufficient quality and quantity grape could be produced in under-cover soilless culture. Since earliness is also achieved in under-cover culture, profitability could also be increased with this under-cover soilless culture. Therefore, soilless culture could be recommended to local farmers for profitable production.

The highest 100 berry weight and berry volume of the present study was classified in "large berry" group according to Çelik (2011) and "medium-sized berry" according to Anonymous (1997).

The differences in TSS content and maturity index values of the treatments were found to be significant. The highest TSS content (14.0%) was obtained from Cocopeat medium and the highest maturity index values were observed in Cocopeat and Perlite:Peat media (with 29.9 and 28.7, respectively). Crop loads and growth medium × crop load interactions did not have significant effects on TSS, acidity, pH and maturity index values (Table 5). Buttaro et al. (2012) reported TSS contents of 'Cardinal' and 'Victoria' cultivars in Perlite:Peat medium respectively as 15.9% and 14.0%. These values comply with the present findings (14.0%). Buttaro et al. (2012) carried out a study in Italy at two different locations with three different grape cultivars in under-cover Perlite:Peat (2:1) medium and reported lower TSS contents for 'Black Magic' and 'Victoria' cultivars (13.6 and 12.0%) than that of 'Cardinal' and 'Victoria' cultivars (15.9 and 14.0%). In present study, TSS content of 'Early Sweet' cultivar in Perlite:Peat medium was measured as 13.0%.

Growth media had significant effects on K and Ca concentrations of the leaves sampled in veraison (Table 6). The highest K concentrations were obtained from Cocopeat (0.67%) and Perlite:Peat (0.66%) media and the highest Ca concentration was obtained from Basaltic Pumice (1.99%) medium. The effects of different crop loads on leaf macro nutrients were not found to be significant (Table 6). It was observed when the mean values were compared with the limit values that K and Ca deficiencies were severe, N was sufficient, P was slightly deficient and Mg was higher than the specified limits (Beyers 1962; Fregoni 1984; Jones et al. 1991).

Effects of different growth media on Mn and Fe concentrations of the leaves sampled from the under-cover grown and nutrient solution-treated plants at veraison were significant (Table 6). The highest Mn concentration was obtained

Table 7 Effects of treatments on stem diameter of vines at maturity and dormant periods in year 2016

Sources of Variation	Stem diameter (mm)	
	Maturity period	Dormant period
Substrate		
Cocopeat	16.86 a*	17.80 a
Perlite:Peat	15.45 b	15.93 b
Basaltic Pumice	16.68 a	18.20 a
LSD 5%	0.21	0.49
Pr > F	<0.0001	0.0004
Crop Load		
10 Clusters	15.73	17.51
15 Clusters	16.32	17.11
LSD 5%	NS	NS
Pr > F	0.8542	0.1324
Interaction		
LSD 5%	0.30	0.69
Pr > F	<0.0001	0.0001

NS Non-significant

*Mean separation within columns by LSD multiple range test at 0.05 level

from Perlite:Peat medium (88.39 mg kg^{-1}) and the highest Fe concentration was obtained from Basaltic Pumice (58.05 mg kg^{-1}) medium. Considering limit values reported by Beyers (1962), Fregoni (1984), Tangolar and Ergenoğlu (1989), Jones et al. (1991), Kacar (1972) and Çelik et al. (1998), Mn, Fe and Zn were evaluated to be sufficient, deficient and excessively deficient, respectively.

The effects of different media on stem diameters (mm) measured at maturity and dormant periods of plants were found to be significant. The greatest values in maturity and dormant periods were obtained from Cocopeat and Basaltic Pumice media and they were placed in the same statistical group. The effects of crop loads on stem diameters (mm) at maturity and dormant periods were not significant (Table 7).

Conclusions

Present findings revealed that quite much earliness was achieved for 'Early Sweet' cultivar with under-cover soilless culture. Besides, resultant crops had satisfactory yield and quality. Since temperature and ventilation can easily be controlled in under-cover cultures, greater yield and better quality could be achieved in soilless cultures. Higher yields and quality mean higher profitability.

Although relatively higher yields were obtained from Perlite:Peat medium and 15-clusters crop load treatment than from the other treatments, locally available and cheaper Basaltic Pumice medium could also be recommended for soilless grape culture. Leaf P, K, Ca, Fe and Zn levels were slightly below the optimum values specified by the earlier researchers (Ecevit 1986; Tangolar and Ergenoğlu 1989; Çelik et al. 1998; Jones et al. 1991; Çelik 2011). Therefore, despite the sufficient yield and quality, it was concluded that these insufficient nutrients should be supplied in future soilless grape cultures.

It was concluded based on present findings that early grape culture was quite possible under controlled greenhouse conditions with the proper growth medium and plant nutrition. Such a culture was also considered as a profitable practice and thus recommended to local farmers.

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Conflict of interest S. Tangolar, P.C. Baştaş, A.A. Torun and S. Tangolar declare that they have no competing interests.

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