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Comparison of open field and protected cultivation of five early table grape cultivars under Mediterranean conditions

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Abstract: The production of grapes for early table consumption is becoming more popular in the Mediterranean region of Turkey. In this study, the cultivation of 5 early table grape cultivars ('Ergin çekirdeksizi', 'Uslu', 'Yalova incisi', 'Cardinal', and 'Perlette') in the open field and under protected cultivation were compared in 2004-2005 and 2005-2006 seasons. For the protected culture, the grapevines were covered on 23 February 2004 and 24 February 2005. The phenologic observations, pomologic analyses, yield variables, and primary shoot growth were determined. When compared to open field production, protected production led to 15-18 days earliness. 'Uslu' was the earliest cultivar in both open field and protected cultivation. The cluster weight, cluster width, and cluster length of cultivars did not vary between the different production treatments. Total soluble solids (TSS) and pH values of both of the production types were similar. For 'Yalova incisi' and 'Cardinal', the yield in open field production was higher than that in protected cultivation. In protected cultivation, the effect of production sites on shoot development was greater than it was in the open field. The highest primary shoot length was observed in 'Uslu' in both treatments.

Key words: Earliness, grapevine, phenological variables, polyethylene sheet

Akdeniz koşullarında beş erkenci sofralık üzüm çeşidinin açıkta ve örtüaltında yetiştiriciliğinin karşılaştırılması

Özet: Türkiyede erken sofralık tüketimde üzüm çeşitlerinin üretimi için Akdeniz Bölgesi popüler hale gelmektedir. 2004-2005 ve 2005-2006 sezonunda yapılan bu çalışmada; bazı erkenci sofralık üzüm çeşitlerinin (Ergin çekirdeksizi, Uslu, Yalova incisi, Cardinal ve Perlette) örtüaltında ve açıkta yetiştiriciliği denenmiştir. Asmalar birinci yıl 23 Şubat'ta, ikinci yıl 24 Şubat'ta örtüaltına alınmıştır. Açıkta ve örtüaltında yetiştirilen asmalarda fenolojik gözlemler, pomolojik analizler, omca başına verim miktarları ve sürgün gelişimleri belirlenmiştir. Örtüaltı yetiştiricilikte, açıkta yetiştiriciliğe göre 15 gün ile 18 gün arasında erkencilik sağlanmıştır. Açıkta ve örtüaltı yetiştiricilikte en erken Uslu çeşidi olgunlaşmıştır. Çeşitlerin salkım ağırlığı, salkım eni ve salkım boyları yetiştirme ortamlarına göre önemli bir farklılık göstermemiştir. Şırada ŞÇKM ve pH değeri örtüaltı ve açıkta benzer bulunmuştur. Yalova incisi ve Cardinal çeşitlerinde omca verimi açıkta yetiştiricilikte, örtüaltı yetiştiriciliğe göre daha yüksek değer vermiştir. Yetiştirme ortamının sürgün gelişimine etkisi örtüaltında, aşıktakilere göre daha fazla olmuştur. Her iki yetiştirme ortamında en fazla sürgün gelişimi Uslu çeşidinde saptanmıştır.

Anahtar sözcükler: Erkencilik, asma, fenolojik safhalar, polietilen örtü

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Introduction

The effective implementation of viticulture in Turkey depends on developing systems that provide the product to the market in traditionally out-of-harvest seasons. One way to accomplish this objective is to develop early production systems (Sivritepe and Rehber 1998). This can be achieved by managing the vineyard as a protected cultivation system, that is, by covering the top and the lateral belts of the vineyard with transparent plastic film (Novello and Palma 2008).

In Turkey, the Mediterranean region has an important role in grape production, producing 667,055 t in 101,155 ha of vineyard (TUİK 2007). The most appropriate ecology for early grapes cultivars that can be marketed easily and for higher prices in domestic and foreign markets is the coastline of the Mediterranean region (Çelik et al. 2005; Söylemezoğlu et al. 2005). Because the east and south Mediterranean regions are characterized by hot and dry summers and moderate winters, grapevine cultivation for the early season world market is being performed here under temporary polyethylene cover (Lavee 2000). Although 90% of the protected cultivation area in Turkey is in the Mediterranean region, only 1% of this area is used for fruit production (Titiz 2003). In Turkey, the use of plastic covers in order to improve early yield for viticulture is relatively new (Tangolar and Gök Tangolar 2003); however, the use of polyethylene (PE) covers in viticulture studies has been rapidly increasing (Gök Tangolar et al. 2007).

Generally, the effect of appropriate ecology and cultivar choices on earliness increases significantly with protected production techniques. For example, protected cultivation provided 26 days earliness with 'Kyoho' grapes in Korea (Son et al. 1992), 14 days earliness with 'Regina dei Vigneti' grapes (Fanizza and Ricciardi 1993) and 22 days earliness with 'Matilde' grapes (Novello et al. 2000) in Italy, 21-25 days earliness with 'Kyoho' grapes in China (Li and Zhang 1994), and 31 and 7 days with 'Perlette' grapes in Macedonia (Mattheou and Grafiadellis 1995).

In studies performed in the Aegean region (İzmir) of Turkey, protected production provided 13-19 days of earliness in the Aegean region (İzmir) (Uzun 1993; Uzun and İltir 1993) and 15-19 days of earliness in the Mediterranean region (Adana) (Ergenoğlu et

al. 1999b). In a study done in Adana (Ergenoğlu et al. 1999a), berries matured 17 and 14 days earlier than open field controls when the grapevines were covered on 16 February and 9 March, respectively. In Antalya, a study on 'Early Cardinal', 'Trakya ilkeren', and 'Uslu' cultivars showed that grapevines grown in protected culture were harvested in late May, while grapevines grown in an open field were harvested at the end of June or at the beginning of July. The yields of the grapevines grown in protected culture were lower than the ones grown in the open field (Uzun et al. 2005). In the present study, we compared the phenological variables, fruit quality, yield, shoot growth, and leaf thickness for some early local and foreign table grapes under protected and open field treatments in Hatay, which is located in Turkey's Eastern Mediterranean region and has the highest effective heat summation.

Materials and methods

This study was conducted in the Mustafa Kemal University, Agriculture Faculty, Dörtöyl Research Station in Hatay, Turkey, during 2004-2005 and 2005-2006 seasons. Dörtöyl Research Station is located at 36°54'N and 36°13'E at 198 m.a.s.l. Dörtöyl has a typical Mediterranean climate; the yearly average temperature is 19.3 °C, with 925 mm precipitation, which primarily falls during winter and spring. 'Ergin çekirdeksizi', 'Uslu', 'Yalova incisi', 'Cardinal', and 'Perlette' cultivars were grafted on 1103 P rootstock and established in 2 × 3 m spaces in 1997 and trained in bilateral cordon trellis.

The control grapevines were grown in open fields. For protected cultivation, plastic tunnel 200 cm in height and 250 cm in width were used. The covering process was started on 23 February of the 1st year and on 24 February of the 2nd year. A 0.30 mm thick polyethylene sheet with ultraviolet (UV) + infrared (IR) + anti-fog (AF) properties was used as the covering material. No additional heating system was installed in the plastic tunnel. The inner and outer temperature values during the 2 years of the study are shown in Figure 1. The experimental design was split-plot with 5 replicates.

Phenological variables, such as determination of bud-break, full bloom, veraison, and ripening were

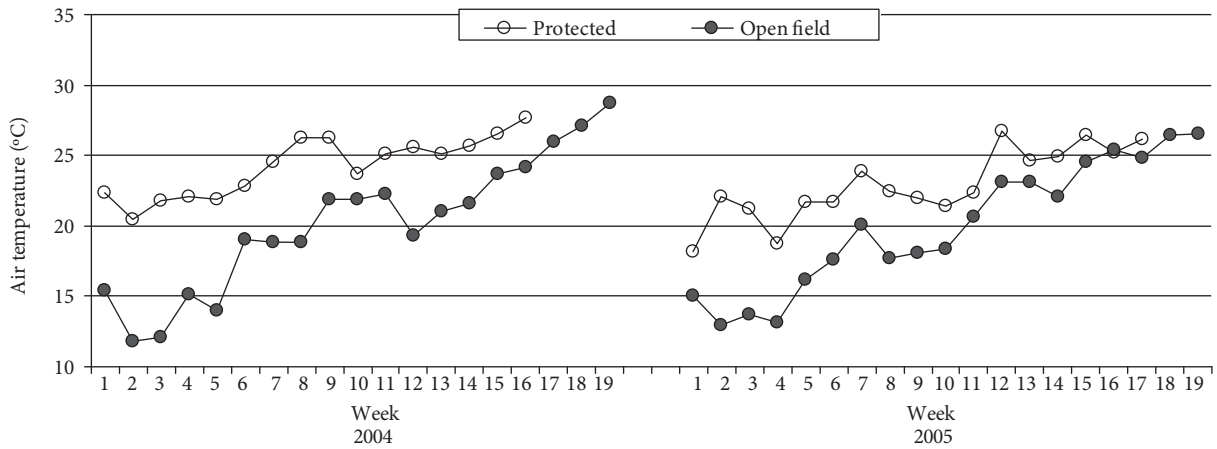


Figure 1. Weekly air temperature in protected and open field cultivation in 2004-2005.

observed from each grapevine. Pomological variables, such as cluster weight (g), cluster width (cm), cluster length (cm), berry weight (g), berry length (mm), berry width (mm), total soluble solids (TSS, %), pH, and acidity (%) were measured and TSS/acidity rate was calculated. Five grapevines for each cultivar were chosen for each treatment. Some of measurements/analyses were conducted according to IPGRI (1997).

The yield was determined for each experimental unit (vine stock) by a scale sensitive to 1 g. Additionally, 2 primary shoots randomly selected from each vine stock, were measured 6 times in 2-week intervals from 31 March to 8 June for the 1st year and from 1 April to 10 June for the 2nd year. When the plants were in full bloom, the leaves against the 1st cluster of 5 primary shoots, which had been selected randomly, were collected and brought to the laboratory in an icebox. Leaf thickness (mg cm^{-2}) was determined on the basis of fresh weight and leaf area.

Variance analysis was performed with MSTAT-C statistical software and means were compared by Tukey test at the 0.05 level.

Results

Phenological observations

According to the mean values of 2004-2005 and 2005-2006 seasons, the phenologic periods were observed earlier in protected plants than in those grown in an open field. As can be seen from Table 1, vines under cover reached bud break 9 days early,

full bloom 14 days early, veraison 16 days early, and maturity 17 days early.

Although there were small differences for every phenologic property investigated between cultivars, the earliest maturing cultivar was 'Uslu' (16 June), the latest maturing cultivar was 'Cardinal' (29 June), and the other cultivars matured a few days before 'Cardinal' (Table 1).

Pomological Analyses

According to the mean values of the 2-year study, the effect of protected cultivation and open field cultivation on cluster properties was not statistically significant. The cluster weight, length, and width were similar in both cultivation environments. However, the differences in cultivars regarding cluster properties were statistically significant. The highest cluster weight and width values were observed in 'Ergin çekirdeksizi' (322.42 g and 10.27 cm, respectively) and the longest cluster length was observed in 'Uslu' (22.39 cm) (Table 2).

Cultivar \times cultivation treatment interactions were significant at 0.05. When the mean values of the 2 years were analyzed together, the berry weight, length, and width of 'Ergin çekirdeksizi' and 'Perlette' were found to be similar in both treatments. However, higher values for these properties were obtained in open field production for 'Uslu' 'Yalova incisi', and 'Cardinal' when compared to protected cultivation. The highest berry weight and width were detected in 'Cardinal' in both treatments. The highest berry

Table 1. The effects of protected and open field cultivations on phenological development dates (days month) (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

Cultivar	Bud break		Full bloom		Veraison		Ripening		Mean
	Open field	Protected	Open field	Protected	Open field	Protected	Open field	Protected	
Ergin çekirdeksizi	26.03	16.03	21.03	24.04	01.05	23.06	06.06	06.07	28.06
Uslu	24.03	17.03	21.03	22.04	30.04	16.06	30.05	24.06	16.06
Yalova incisi	27.03	19.03	23.03	25.04	02.05	20.06	06.06	05.07	26.06
Cardinal	30.03	21.03	25.03	24.04	02.05	27.06	12.06	08.07	29.06
Perlette	22.03	14.03	18.03	23.04	30.04	22.06	10.06	05.07	28.06
Mean	26.03	17.03	21.03	24.04	22.06	22.06	06.06	04.07	17.06

Table 2. The effects of protected and open field cultivations on some of the cluster properties (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

Cultivar	Cluster weight (g)		Cluster length (cm)		Cluster width (cm)		Mean
	Open field	Protected	Open field	Protected	Open field	Protected	
Ergin çekirdeksizi	326.76	318.08	322.42 a ¹	19.96	19.36	19.66 b	10.27 a
Uslu	195.26	189.98	192.62 bc	22.90	21.88	22.39 a	8.51 bc
Yalova incisi	258.30	216.94	237.62 bc	17.72	17.32	17.52 cd	9.18 b
Cardinal	286.70	203.96	245.33 b	19.34	18.36	18.85 bc	9.11 b
Perlette	213.02	157.42	185.22 c	17.68	16.80	17.24 d	8.12 c
Mean	256.01	217.28	19.52	18.74	9.08	9.00	9.00

¹Means followed by different letters in each column are for cultivar comparisons and indicate significant difference by Tukey's test at 0.05.

length was obtained in 'Yalova incisi'. 'Perlette' gave the lowest results with respect to these properties (Table 3).

While the differences regarding the acid and TSS/acidity values were found to be significant for the cultivation treatments, no significant differences were found for soluble solids and pH values. TSS contents were 14.68% and 14.82% in open field and protected cultivation, respectively. The pH means were similar for open field (3.08) and protected cultivation (3.09). The acid content was higher in protected cultivation (0.74%) than open field (0.65%). This may be caused by the fact that the maturity index of protected cultivation (20.62) was less than that of open field cultivation (23.21) (Table 4).

The differences between the cultivars in TSS, acidity, TSS/acidity and pH values were statistically significant. The TSS value of 'Perlette' (16.01%) was significantly higher than that of the others. The acid content was found to be the highest in 'Ergin çekirdeksizi' (0.81%) and lowest in 'Yalova incisi' (0.58%). The highest values of maturity indices and pH were seen in 'Yalova incisi' (25.12 and 3.32, respectively) and in 'Cardinal' (23.84 and 3.25, respectively), while the lowest values were seen in 'Ergin çekirdeksizi' (17.84 and 2.79, respectively) (Table 4).

Yield and vegetative growth

As presented in Table 5, cultivar \times cultivation treatment interactions were statistically significant. The cultivars were affected differently by the production sites based on the mean yields of 2004-2005 and 2005-2006 seasons. The yield of 'Ergin çekirdeksizi', 'Uslu', and 'Perlette' cultivars were similar in the 2 treatments, while 'Yalova incisi' and 'Cardinal' cultivars yielded more fruit in open field production than in protected production. The place of cultivation was found to be important for leaf thickness, with the values from open field production (21.26 mg cm⁻²) being higher than those from protected production (20.16 mg cm⁻²). The leaf thickness for 'Yalova incisi' was the highest (21.66 mg cm⁻²), while the leaf thickness of 'Ergin çekirdeksizi' was the lowest (20.08 mg cm⁻²) (Table 5).

Based on the means of the 2 years, the shoot elongation of plants in protected cultivation was greater than that of plants grown in open fields.

Additionally, based on the shoot measurement in the last period, 'Uslu' was the most rapidly growing cultivar in both open field and protected production. The shoot development of 'Yalova incisi' and 'Perlette' cultivars in the open field were found to be the lowest (Figure 2).

Discussion

The cultivation of early maturing grape cultivars is important in the Mediterranean region (Söylemezoğlu et al. 2005). Maturation of covered vines in subtropical regions is enhanced by about 3 weeks with early cultivars (Lavee 2000). In the present study comparing protected and open field cultivation, 'Perlette' fruit was produced 15 days earlier and 'Cardinal' matured 18 days earlier under protected cultivation. Uzun (1993) reported that covering the grapevines with plastic is effective in speeding up phenologic stages; the 'Perlette' cultivar matured 15-17 days and the 'Bağdat siyahı' matured 16-10 days earlier in that study. In similar studies (Uzun and İler 1993; Ergenoğlu et al. 1999a; Çoban 2004), it was seen that bud break, blooming, veraison, and maturity stages could be pushed back by days. As Uzun and Özbaş (1995) reported, this is because of the warmer temperature in greenhouses and tunnels than in open fields, which satisfies the plants' heat needs faster. In a study done in Adana (Ergenoğlu et al. 1999b), the effects of covering time on earliness was investigated and it was seen that if plants were covered on 23 February, 'Uslu' and 'Perlette' matured on 11 and 18 June, respectively. The findings of the present study are similar to those found by Ergenoğlu et al. (1999b) with respect to earliness period. In a 2-year study done in Manisa, (Aegean region), 'Yalova incisi' grown in protected treatment matured on 17-20 June and 'Cardinal' matured on 25-29 June (Çoban 2004). In our study, 'Yalova incisi' matured on a similar date (18 June), while Cardinal matured 5-9 days (20 June) earlier.

The cluster weight, cluster length, and cluster width of the cultivars did not show any differences between the different cultivation modes. Indeed, Uzun (1993) also reported that there were no differences between cultivation sites in cluster weight, length, and width for 'Perlette' and 'Bağdat siyahı' cultivars. Similarly, Çoban (2004) found that the effect of the protected

Table 3. The effects of protected and open field cultivations on some of the berry properties (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

Cultivar	Berry weight (g)		Berry length (mm)		Berry width (mm)		Mean	
	Open field	Protected	Open field	Protected	Open field	Protected		
Ergin çekirdeksizi	2.34 A ¹ d ²	2.38 Ad	2.36 d	16.86 Ad	16.82 Ac	16.84 d	14.50 Ac	14.51 c
Uslu	4.88 Ac	4.07 Bc	4.48 c	21.00 Ac	19.82 Bb	20.41 c	19.08 Ab	18.61 b
Yalova incisi	6.11 Ab	5.04 Bb	5.58 b	25.46 Aa	23.50 Ba	24.48 a	19.64 Ab	19.04 b
Cardinal	7.38 Aa	5.66 Ba	6.52 a	22.42 Ab	20.44 Bb	21.43 b	22.62 Aa	21.66 a
Perlette	2.01 Ad	1.94 Ad	1.98 d	14.70 Ae	14.24 Ad	14.47 e	14.08 Ac	14.03 c
Mean	4.55 A	3.82 B	20.09 A	18.96 B	17.98	17.16		

¹Means followed by different capital letters are for cultivation treatments (open field vs. protected) and indicate significant difference by Tukey's test at 0.05.

²Means followed by different lowercase letters in each column are for cultivar comparisons and indicate significant difference by Tukey's test at 0.05.

Table 4. The effects of protected and open field cultivations on grape juice (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

Cultivar	TSS (%)		Acidity (%)		TSS/acidity		pH		Mean			
	Open field	Protected	Open field	Protected	Open field	Protected	Open field	Protected				
Ergin çekirdeksizi	14.04	14.16	14.10 c ¹	0.76	0.86	0.81 a	18.66	17.02	17.84 c	2.76	2.82	2.79 c
Uslu	14.32	14.38	14.35 bc	0.72	0.76	0.74 ab	20.44	19.32	19.88 bc	3.09	3.02	3.06 b
Yalova incisi	14.52	14.24	14.38 bc	0.53	0.64	0.58 d	27.58	22.66	25.12 a	3.28	3.35	3.32 a
Cardinal	14.54	15.26	14.90 b	0.56	0.71	0.64 cd	25.82	21.86	23.84 a	3.22	3.27	3.25 a
Perlette	15.96	16.06	16.01 a	0.68	0.74	0.71 bc	23.56	22.26	22.91 ab	3.04	2.99	3.02 b
Mean	14.68	14.82	0.65 B ²	0.74 A	23.21 A	20.62 B	3.08	3.09				

¹Means followed by different lowercase letters in each column are for cultivar comparisons and indicate significant difference by Tukey's test at 0.05.

²Means followed by different capital letters are for cultivation treatments (open field vs. protected) and indicate significant difference by Tukey's test at 0.05.

Table 5. The effects of protected and open field cultivations on yield and leaf thickness (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

Cultivar	Yield (kg vine ⁻¹)		Mean	Leaf thickness (mg cm ⁻²)		Mean
	Open field	Protected		Open field	Protected	
Ergin çekirdeksizi	4.33 A ¹ b ² c	5.15 Aa	4.74 a	20.56	19.60	20.08 e
Uslu	5.40 Aab	4.73 Aa	5.07 a	21.55	20.17	20.86 b
Yalova incisi	6.25 Aa	4.55 Ba	5.40 a	22.12	21.19	21.66 a
Cardinal	7.10 Aa	4.82 Ba	5.96 a	20.90	20.40	20.65 c
Perlette	3.52 Ac	2.56 Ab	3.04 b	21.15	19.46	20.31 d
Mean	5.32 A	4.36 B		21.26 A	20.16 B	

¹ Means followed by different capital letters are for cultivation treatments (open field vs. protected) and indicate significant difference by Tukey's test at 0.05.

² Means followed by different lowercase letters in each column are for cultivar comparisons and indicate significant difference by Tukey's test at 0.05.

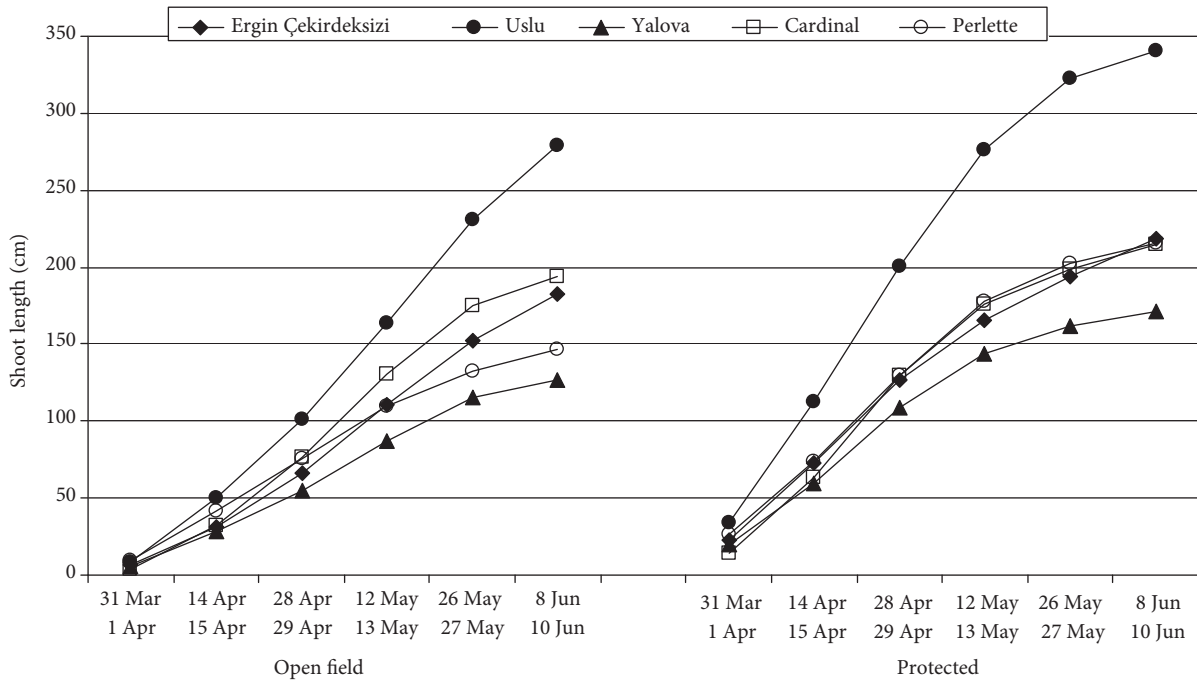


Figure 2. The effects of open field and protected cultivations on shoot length (cm) (mean of 2004-2005 and 2005-2006 seasons) for 5 grape cultivars grown under Mediterranean conditions.

cultivation on the cluster's quality properties was not significant.

The berry weight, berry length, and berry width of 'Uslu', 'Yalova incisi', and 'Cardinal' cultivars were

all higher in open field production than in protected production. In 'Ergin çekirdeksizi' and 'Perlette', these properties yielded similar values in both production types.

In a study conducted Ergenoğlu et al. (1999a) in which 7 grape cultivars and 2 different covering times were investigated, it was determined that there were no significant differences in soluble solids according to the cultivation place. However, they reported that grapevines cultivated in a protected treatment yielded higher acidity and lower maturity indices than those grown in open fields. Our findings are consistent with the conclusion of Ergenoğlu et al. (1999a).

Early grape maturation, under protected cultivation, is a general phenomenon. However, the yield of vine varies according to the production conditions. In our study, the yield in protected cultivation was lower than that in open field for 'Yalova incisi' and 'Cardinal'. Uzun et al. (2005) reported that although protected cultivation can lead to earlier fruit by backdating the harvest time, a decrease in production was observed. Originally, yields under such conditions were low; however, their higher market prices compensated for this (Lavee 2000).

As reported by Uzun (1993) and Çoban (2004), the shoot elongation of the grapevines grown in protected cultivation was higher than that of the

ones grown in open fields. This was also apparent in our study (Figure 2). Indeed, protected cultivation is known to increase vine leaf area by improving vegetative components such as shoots and leaves (Novello and Palma 2008).

In conclusion, the protected cultivation resulted in 15-18 days earliness when compared to open field production. The fruit quality measurements such as cluster characteristics, TSS, pH, and berry width indicated that the protected cultivation did not decrease the quality characteristics. Thus, our results indicate that protected cultivation for early table grape production is promising for the Eastern Mediterranean region. Protected cultivation is more economical than open field growing. Because of this, in order to improve the protected production of grapes, topics such as solar heated plastic houses with water-filled or heated heat storage bags, or heated plastic houses should be investigated.

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