Excessive Pruning Levels in Young Grapevines (*Vitis vinifera* L. cv. Sultan 7) Cause Water Loss in Seedless Cluster Berries

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**ABSTRACT**

Late-season dehydration is known as a type of berry shrivel and it is often associated with wine grapes. This study is different from other berry shrivel studies as it focuses on seedless grape cv. Sultan 7 (*Vitis vinifera* L.) and aims to determine the effects of different pruning levels (90, 150, 180 buds per vine), leaf removal (LR) (25%, 50% per shoot) treatments on vine yield, and the number of harvested clusters. Additionally, we aim to find the effects of treatments on the number of unhealthy clusters with shriveled (S) berries. Although treatments were conducted under the same irrigation practices and determined close leaf water potential values, S berries were not obtained from the vines with 90 buds per vine treatment. Thus, S berries were determined in the lower side of unhealthy clusters together with non-shriveled (NS) berries in treatments of 150 and 180 buds per vine. It was found that the total soluble solids content and titratable acidity of S berries were higher than NS. While high pruning levels per vine enabled to obtain more clusters, the expected yield was negatively affected due to the quantity of the unhealthy cluster. Significant polynomial regression was observed between the number of harvested and unhealthy clusters in 2016 (\(R^2 = 0.69\)) and 2017 (\(R^2 = 0.76\)). In this research, it was hypothesized that the water losses in S berries of unhealthy clusters in overloaded vines (150, 180 buds per vine) were caused by obtaining more harvested clusters compared to the 90 buds per vine treatment.

**KEYWORDS**

Berry shrivel; late-season dehydration; leaf water potential; unhealthy cluster; water loss

**Introduction**

The production and export values of raisin in the world indicate that Turkey is one of the most important countries. Aegean Region is an economically important location for the cultivation of the seedless grape, by means of its ecological superiority and historical viticulture experience of the growers. Due to its geographical location, the region has a very fertile soil character, plenty of sunshine, an available water supply, and a high potential for grape production (Söylemezoğlu et al., 2016; Teker et al., 2018, 2020).

Pruning practices directly affect the shoot number and the potential crop level. Different pruning treatments may alter the vine yield, leaf area/crop ratio of vines, which change the length of the ripening period of berries (Allebrand et al., 2017; Greven et al., 2015; Marcon Filho et al., 2016; Miele and Rizzon, 2013). As the vines are pruned leaving more buds, it causes delayed berry ripening, reduces berry quality and often increases acidity (Huglin and Schneider, 1998; Keller, 2015; Winkler, 1958). Although many studies have focused upon the effect of water stress on yield, grape ripening and wine quality (Baeza et al., 2019; Keller et al., 2008; Ojeda et al., 2002; Talaverano et al., 2017), there are...
limited studies on the effects of different pruning levels on seedless grape varieties under the same irrigation practices.

Preferred trellis systems and pruning methods are special to cultivars and may alter the canopy management for vineyards in different regions. Thereby, the structure of the canopy affects the fruit temperatures (Novello et al., 2015) and the water capacity of the vine (Williams and Ayars, 2005). In warm climates, high daily temperatures in a region and water status of the berries are important in terms of berry features and composition (Deloire and Hunter, 2005). Moreover, as the temperatures rise, greater evaporation potential could occur in the cluster zone (Williams, 2012). In this case, the water use of berries may increase and the lack of vapor pressure around the berries may change (Rebucci et al., 1997). On the other hand, in seedless grape cultivation, there are studies related to the fact that excessive pruning levels per vine caused water loss in the berries under the same irrigation and fertilization practices in Aegean Region (Altındaşlı, 1995; Konuk, 1991). In recent years, field observations in the region confirm that growers leave too many buds (150–180 buds) per vine to obtain more clusters. However, they complain of having problems with the occurrence of water loss in some berries at the lower side of the clusters (Teker, 2019).

It is stated in some studies the cause of water loss in berries is based on physiological disorders. Berry shrivel is a kind of physiological disorder that affects berry composition and features (Hall et al., 2011; Knoll et al., 2010). In a study, berry shrivel is described in four common types in grape with specific symptoms; sunburn, sugar accumulation disorder, bunch stem necrosis, and late-season dehydration. Late-season dehydration is another type of berry shrivel that may affect berries late in ripening but before commercial harvest (Krasnow et al., 2010). According to McCarthy (1999), for this type of shrivel, berries lose weight due to water loss, and sugars are concentrated. Although studies about berry shrivel have increased recently (Bondada, 2016; Crespo Martinez et al., 2019; Hall et al., 2011; Keller et al., 2016), the causes of berry shrivel are still unclear.

Current study aims (1) to investigate the effect of pruning levels and leaf removal treatments on cluster number and vine yield, (2) to determine the effect of the increasing number of clusters on the occurrence of late-season dehydration in the late season (before harvest), (3) to compare the shreveled and non-shrivelled berries in terms of basic maturity parameters, (4) to find the effect of overloaded grapevines on the number of unhealthy clusters and the occurrence of water losing berries on the same clusters.

Materials and Methods

Plant Material and Location

The study was conducted over two consecutive years (2016–2017 vegetation period) in the experimental field at Viticulture Research Institute (MVRI) in Manisa that located in Aegean Region, west side of Turkey. Four years old vines (Vitis vinifera L. cv. Sultan 7) grafted onto 1103 Paulsen rootstocks were used as plant material. Vines were planted 2.0 × 3.0 m distance and trained as goblet system on V shape trellis. Climatic data were obtained from the climatic station (METOS, Climate Station). The phenological stages were visually evaluated according to the EL scale (Coombe, 1995). The vineyard, located on moderately deep, well-drained, clay loam soil and all plants were in the same fertilization and irrigation practices. The amount of fertilizer per vine was applied as 66.26 g N, 36.14 g P₂O₅, and 48.19 g K₂O in the first year, 72.28 g N, 42.16 g P₂O₅ and 54.21 g K₂O in the following year. The vineyard was drip irrigated. Drip laterals with one line per plant row were used. The distance of the emitters with a nominal flow rate of 4 L h⁻¹ was 50 cm. Laterals were placed 50 cm above the ground. All vines in the study were irrigated when the available water decreased 50% in effective root depth (0.90 m) in soil. Irrigation was applied from fruit set until 15 days before harvest in August. The total amount of water was approximately 170 mm (8 times) in 2016 and 192 mm (9 times) in 2017. The study plots were adjusted in a randomized complete block design with three blocks and, six parcels in each block.
**Pruning Levels and Leaf Removal Treatments**

Three pruning levels were applied on vines with the cane-pruning system; 90 buds (15 buds on six canes), 150 buds (15 buds on 10 canes), and 180 buds (15 buds on 12 canes) per vine, respectively. LR treatments were conducted manually. At the end of the blooming, the main mature leaves which remained under the cluster zone were removed as a standard application for all vines. In LR treatments of this study, leaves and lateral shoots were removed only once at berry set (EL29) in each year. Two LR levels were applied, including 25% LR (one leaf in every three nodes after the sixth node above the cluster zones) and 50% LR (one leaf in every other leaf after the sixth node above the cluster zones) on each shoot of the vines. The treatments of 90 buds per vine and 25% LR per shoot were determined as the control based on previous studies in the region (Ilgın, 1997; İlhan and İlter, 1992). Pruning levels and LR treatments per vine were applied as; 90 buds/vine + 25% LR (control), 90 buds/vine + 50% LR, 150 buds/vine + 25% LR, 150 buds/vine + 50% LR, 180 buds/vine + 25% LR, and 180 buds/vine + 50% LR.

**Classification of Clusters and Berries**

Morphological observations on clusters and berries were performed between the véraison and harvest (EL35-EL38). In treatments of 90 buds per vine, all the berries were determined healthy. In contrast, it was detected that some berries on cluster began to lose water in treatments of 150 buds per vine and 180 buds per vine. Accordingly, the clusters in which all berries were healthy, marked as healthy cluster (Figure 1a). The clusters in which non-shriveled (NS) and shriveled (S) berries were together (Figure 1b), marked as the unhealthy cluster. After these markings, all clusters were checked for the last time before harvest and new unhealthy clusters were marked. Besides, the number of harvested, healthy and unhealthy clusters were counted and data were recorded.

![Figure 1. An illustrative picture of the classification of clusters and berries. (a) Healthy (H) cluster (b) Unhealthy (UH) cluster.](image-url)
Leaf Water Potential

Leaf water potentials ($\Psi_{\text{leaf}}$) were determined by using a Scholander Pressure Chamber (Scholander et al., 1965). Measurements were carried out in three leaves (fully expanded, freshly cut, and healthy) from each of the treatments between 12:00 and 13:30 h, Pacific Daylight Time (PDT) in four days of the year (DOY).

Yield Components, Composition of Healthy and Shriveled Berries

Harvest was conducted in EL 38 (August 24–25) in both years when the total soluble solids (TSS) content reached 21–22 °Brix (control treatment). Yield, harvested cluster number and berry weight were calculated and each cluster harvested manually. A sample of NS and S berries (Figure 1b) (50 berries per sample) in different parts of various clusters in each replicate were collected at harvest and immediately transported to the laboratory. Additionally, the TSS (°Brix), titratable acidity (TA) (tartaric acid; g·L$^{-1}$), and pH were determined according to Ough and Amerine (1988).

Statistical Analysis

The statistical analysis of all parameters was performed using JMP 13 statistical software. Results of yield and cluster numbers were analyzed using the Least Significant Difference (LSD) test ($P \leq 0.05$). The t-test was used to determine statistically significant differences between NS and S berries in terms of basic maturity parameters ($P \leq 0.05$). The regression equations between harvested and unhealthy clusters were performed using a polynomial (quadratic) model ($P < .01$).

Results

Weather Data and Phenological Observations

The average annual air temperature in 2016 was slightly higher than in 2017. The average temperatures from June to July 2016 were found higher than the year 2017. The total precipitation was 649.2 mm in 2017 and 615.4 mm in 2016; the difference was found 33.8 mm (Table 1).

| Months  | 2016 Average Temp. (°C) | 2016 Average Max. Temp. (°C) | 2016 Precipitation (mm) | 2017 Average Temp. (°C) | 2017 Average Max. Temp. (°C) | 2017 Precipitation (mm) |
|---------|-------------------------|-------------------------------|-------------------------|-------------------------|-----------------------------|-------------------------|
| March   | 12.2                    | 26.7                          | 123.4                   | 12.1                    | 25.6                        | 75.0                    |
| April   | 18.4                    | 33.4                          | 10.6                    | 15.6                    | 31.6                        | 20.2                    |
| May     | 20.0                    | 34.8                          | 40.6                    | 20.6                    | 35.1                        | 41.6                    |
| June    | 28.5                    | 42.6                          | 18.8                    | 25.3                    | 41.5                        | 17.8                    |
| July    | 28.4                    | 42.1                          | 0.0                     | 27.9                    | 45.6                        | 2.6                     |
| August  | 28.3                    | 40.3                          | 0.8                     | 27.9                    | 39.0                        | 1.6                     |
| MAT (°C)†| 17.4                   | 32.1                          |                         | 16.8                    | 31.0                        |                         |
| TP (mm)‡|                         | 615.4                         |                         |                         | 649.2                       |                         |

† The average annual temperatures. ‡ Total precipitation values in years.

| Years  | Budburst | Anthesis | Veraison | Harvest |
|--------|----------|----------|----------|---------|
| 2016   | 16 March | 10 May   | 16 July  | 25 August |
| 2017   | 20 March | 16 May   | 14 July  | 24 August |

†Days of the year.
The phenological stages of the vines did not show major differences yearly. Blooming (DOY 131–136) occurred on May 10th in the first year and on May 16th in the following year. Véraison (DOY 198–195) was observed on July 16th in 2016 and on July 14th in 2017. Harvest (DOY 238–236) was conducted on August 25th and on August 24th, respectively (Table 2).

**Yield (Kg/vine)**

In both years, although there was no statistically significant difference among treatments ($P \leq 0.05$), it was obvious that the highest yield was recorded in 150 buds/vine + 50% LR treatment with the values of 19.0 kg/vine and 14.4 kg/vine in 2016 and 2017 respectively (Figure 2a). When the yield was compared in terms of the years, the highest reduction was found in 150 buds/vine + 25% LR (36.57%). Means of pruning level, the highest reduction in the yield was 30.11% and obtained in the treatment of 180 buds/vine (Figure 2b). The mean values of LR did not impact yield statistically, but values showed that the vine yield obtained from 50% LR treatment per shoot was higher compared to 25% LR treatment (Figure 2c).

![Figure 2](image-url)

**Figure 2.** Effect of treatments on the yield of ‘Sultan 7’ vines in 2016–2017 (a). *Means values followed by a different letter are significantly different amongst pruning level (PL) (b) and leaf removal (LR) (c) means according to LSD test at $P \leq 0.05$, ($n = 15$ vines, in each treatment). ns, non-significant.

No statistically significant difference was found in the number of the harvested cluster among the treatments in both years. It was determined that the major decrease was in the treatment of 180 buds/vine + 50% LR (- 43.51%), compared to the previous year. While the highest cluster number was found in the treatment of 180 buds/vine + 50% LR in 2016, it was determined in the treatment of 150 buds/vine + 50% LR in the following year. But, the lowest cluster number was obtained from 90 buds/vine + 25% LR treatment in both 2016 and 2017 (Figure 3a). Comparing the years, the mean values of
pruning levels showed that the cluster number decreased by 23.77% in 150 buds/vine treatment in 2016 while 38.17% in 180 buds/vine treatment in 2017 (Figure 3b). The mean values of LR showed that the number of clusters decreased in both treatments. However, unlike the first year of study, the difference in mean values of LR was not found statistically significant in the following year (Figure 3c).

**Leaf Water Potential**

$\Psi_{md}$ were measured on the DOY 191, 203, 223, and 230 in 2016; DOY 186, 201, 220, and 229 in 2017 (Figure 4). $\Psi_{md}$ measurements in 2016 showed that the values varied between -1.30 MPa and −1.93 MPa. Although there were no significant differences among the treatments in 2016, $\Psi_{md}$ values of 180 buds per vine + 50% LR were lower than those of other treatments in all days. After véraison (DOY 203, 223, and 230), all $\Psi_{md}$ measurements were determined to be at a high-stress level and above. In the last measurement of the first year (DOY 230), the differences in mean values of both pruning levels and leaf removal were found to be significant statistically. Pruning levels the lowest mean $\Psi_{md}$ value was determined in 180 buds per vine (Figure 4a).

In 2017, the $\Psi_{md}$ values were determined in a range of −1.30 MPa and −1.78 MPa. Except for the first measurement day (DOY 186), the differences between the $\Psi_{md}$ values were not statistically significant. It was determined that the main effect of leaf removal was more efficient than pruning levels on that day. Toward the last $\Psi_{md}$ measurement day, although there was no significant difference between the treatments, the effect of leaf removal disappeared in DOY 220 and 229. The differences were found significant statistically only in terms of the main effect of pruning levels in DOY 229.
The effect of pruning levels was found to be significant in the second year as well as in the first year of the study.
Number of Unhealthy Cluster and Relationship with Harvested Clusters

Some berries on clusters began to lose water content three weeks after véraison in treatments of 150 buds per vine and 180 buds per vine (not 90 buds per vine) (Table 3).

The data are mean values obtained in 2016 and 2017. No statistical analysis has been made and the distribution of healthy and unhealthy clusters in the harvested cluster is shown.

The highest unhealthy cluster number was found in the treatment of 180 buds/vine + 50% LR in the first year whereas it was determined 150 buds/vine + 50% LR in the second year. The distribution of the unhealthy clusters in number of harvested clusters were calculated as 16.07%, 31.90%, 34.04%, and 39.67% in treatments of 150 buds/vine + 25% LR, 150 buds/vine + 50% LR, 180 buds/vine + 25% LR, and 180 buds/vine + 50% LR respectively in 2016. In 2017, these rates decreased to 6.01%, 15.63%, 15.62% and 12.69% respectively (Table 3).

It was determined that increased bud numbers per vine raised the number of harvested clusters. The mean number of harvested clusters obtained from all treatments was 68.3 in 2016. In the second year, the mean number of harvested clusters determined as 46.7. The number of harvested clusters was determined to have decreased by 31.62% in the second year compared to the previous year. In parallel to this reduction in the number of harvested clusters, a decrease in the unhealthy cluster number also occurred, the mean number of unhealthy clusters determined as 21.5 in the first year and as 6.0 in the second year. Accordingly, a 72.09% decrement was recorded. (Table 3). A relationship was found between the harvested cluster and unhealthy cluster numbers in four treatments (overloaded vines) (Figure 5). The number of unhealthy clusters increased with the increment in the harvested cluster. The relationship between the number of harvested and unhealthy clusters in both years was significant (P < .01). The polynomial slopes had high reasonable R² values (R² = 0.69 in 2016 and R² = 0.76 in 2017) (Figure 5a,b).

Comparison of NS and S Berries

S berries which began to lose their ovary and became irregular-shaped, flaccid, and soft in approximately three weeks after véraison, were obtained only from the lower side of the unhealthy clusters. Pedicel of S berries and rachis of unhealthy clusters were found to be green in color like NS berries and rachis of healthy clusters (Figure 6).

Significant differences (P ≤ 0.05) were determined between NS and S berries in terms of values of berry weight, TSS, pH, and TA (Table 4). The weight of the S berries sampled from the lower side of the unhealthy clusters was determined to be about half of the NS berries in both years. The TSS of NS berries (19.2 °Brix; 20.4 °Brix) was less than the TSS of S berries (25.1 °Brix; 22.0 °Brix) in both 2016 and 2017 growing seasons respectively. The difference of TSS values between NS and S berries in 2016 was found high compared to 2017. The pH value of S (3.2; 3.1) was lower than that of NS berries (3.5; 3.6). Thus, the TA values in 2016 and 2017 were obtained higher in S berries (7.2 g·L⁻¹; 8.4 g·L⁻¹) when compared to NS berries (5.0 g·L⁻¹; 3.4 g·L⁻¹) respectively. It was determined that S berries were more acidic though the TSS content of grape juice was increased (Table 4).

### Table 4. Differences of non-shriveled (NS) and shriveled (S) berries in terms of berry weight (BW), total soluble solids (TSS), pH, and titratable acidity (TA) values.

| Berry Type | BW (g) | TSS (°Brix) | pH | TA (g·L⁻¹) |
|------------|--------|------------|----|------------|
|            | 2016   | 2017       | 2016 | 2017 | 2016     | 2017     |
| NS         | 1.3 ± 0.1 | 1.4 ± 0.2 | 19.2 ± 1.0 | 20.4 ± 1.3 | 3.5 ± 0.1 | 3.6 ± 0.1 | 5.0 ± 0.7 | 3.4 ± 0.4 |
| S          | 0.6 ± 0.1 | 0.6 ± 0.1 | 25.1 ± 1.7 | 22.0 ± 1.2 | 3.2 ± 0.1 | 3.1 ± 0.1 | 7.2 ± 1.2 | 8.4 ± 0.8 |
| t-test     | *      | *          | *      | *          | *      | *          | *      | *          |

*Means differ significantly at P ≤ 0.05 (t-test). Data are means ± SE. Fruit characteristic; berry weight. Juice characteristics; total soluble solids (TSS), pH, and titratable acidity (TA).
Discussion

In this study, different pruning levels strongly affected the number of harvested clusters and yield. The mean number of harvested clusters per vine of 'Sultan 7' increased by rising the number of buds in both years (Figure 3b). In previous studies to determine optimum pruning levels for seedless grape varieties showed that as the number of buds per vine increased, vine yield and the cluster number also increased (Christensen et al., 1994; Fawzi et al., 2010; Salem et al., 1997; Teker et al., 2020). It was considered that the high number of buds left per vine (150 buds per vine and 180 buds per vine) in the

Figure 5. The relationship between values of the number of total harvested clusters and the number of unhealthy clusters of cv. Sultan 7 vines in 2016 (a) and 2017 (b). The data points are the values of treatments of 150 buds/vine + 25% LR, 150 buds/vine + 50% LR, 180 buds/vine + 25% LR, and 180 buds/vine + 50% LR. The lines represent the polynomial equation of regression both for 2016 [$R^2 = 0.69$ (n=59), ($P < .01$)] and for 2017 [$R^2 = 0.76$ (n=58), ($P < .01$)].
first year cause decrement in the cluster number in the following year in all LR practices (25% and 50% per shoot). This decrease of cluster number per vine was more in high pruning levels. Therefore, it was concluded that excessive pruning levels affect the cluster number much more than LR treatments, as the main factor. Lider et al. (1973) reported that there may also be less shoot development and weak inflorescence because of the high number of buds on vines. Besides, Christensen et al. (1994) found that the high bud number per vine causes a lower percent of bud burst and corresponding lower inflorescence per bud.

In the present study, \( \Psi_{md} \) were measured 4 times in both years. Smith and Prichard (2002) reported that the values of leaf \( \Psi_{md} \) from \(-1.40\) MPa to \(-1.60\) MPa were accepted high-level stress on leaves between véraison and harvest for wine grapes. The \( \Psi_{md} \) values obtained in this study showed that more stress conditions tended to occur in overloaded vines and 50% LR treatments. It was determined that the water loss of S berries occurred in overloaded vines (150 and 180 buds per vine) under the same irrigation practices. However, there was no finding of the occurrence of S berries in the treatment of 90 buds per vine. It was stated that high pruning levels may cause a decrement in \( \Psi_{md} \) values (Dufourcq et al., 2005). Moreover, Bahar et al. (2011) reported that the classification of stress levels of \( \Psi_{md} \) may vary according to cultivars. In this study, it was thought that the classification of \( \Psi_{md} \) mentioned above might change for seedless grape cultivars like 'Sultan 7'. Especially making a new classification was considered important for seedless grape cultivars because of the high vegetative growth.

One of the consequences of high pruning levels per vine is the water loss in S berries in the unhealthy clusters after véraison. Another berry shrivel study reported that “the disorder can influence some clusters, and occasionally only parts of clusters, on an asymptomatic vine, while other clusters appear outwardly normal” (Krasnow et al., 2009: 25). This finding supports the reason that we could not obtain unhealthy clusters from all vines in the experiment field. Water loss occurred in S berries sampling from the lower side of the unhealthy cluster in treatments of 150 buds and 180 buds per vine.
in both LR treatments (25% and 50%). But in the treatment of 90 buds per vine, no S berry was obtained in both LR ratios.

Different pruning levels reveal the relationship between the harvested and unhealthy cluster, which is quite sensitive to change in bud numbers per vine. As the total number of harvested clusters in 2016 increased, the unhealthy cluster increased. In contrast, both of them were decreased in the second year. The relationship between the number of harvested and unhealthy clusters in both years was found highly significant ($P < .01$) as $R^2 = 0.69$ in 2016, and $R^2 = 0.76$ in 2017 (Figure 5). Several studies conducted in the region have ascribed that this problem may be related to the amount of cluster or yield on vines (Altindişli, 1995; İlter et al., 1992; Konuk, 1991). Furthermore, Altindişli (1995) emphasized that clusters may negatively be affected to sustain vegetative/generative balance in over-loaded vines where insufficiently irrigated vineyards.

In this study, two different berry forms were obtained from the lower side of the unhealthy clusters in harvest; NS and S berries were compared in terms of berry weight, TSS, pH, and TA values. Statistically, significant differences were found among berries in both years ($P \leq 0.05$). The weight of the S berries was determined to be about half of the NS berries in both years due to water loss. Water loss in the S berries was most likely increased the dry matter concentrations. For this reason, the TSS of S berries increased significantly compared to NS berries. TSS of S berries was found as 25.1 °Brix and 22.0 °Brix in consecutive years. On the contrary, the TSS content of NS berries was determined as 19.2 °Brix and 20.4 °Brix (Table 4). Besides, it was determined that the TA of S berries was higher than the TA of NS berries. pH values of S berries were found as low.

Krasnow et al. (2010) classified berry shrivel in four common types with various symptoms as sunburn, bunch stem necrosis, sugar accumulation disorder, and late-season dehydration. It was important for us to classify S berries obtained in the present study. Our findings were not related to sunburn because the skin color of S berries was obtained in yellow-green color. There was no indication of brownish color on all surfaces of berry skins. Because the rachis of all clusters and pedicels colors of S berries were determined as green, the berries did not relate to bunch stem necrosis symptoms. Moreover, we determined that S berries were not associated with sugar accumulation disorder since the TSS content of NS berries was lower than S berries and the first visible symptoms of S berries were recorded approximately 3 weeks after ‘véraison.’ When all the findings were evaluated, it was determined that S berries lost water content. Because of the high contents of TSS and TA values of S berries, we proved that these berries showed the most similar symptoms to late-season dehydration classification. In literature, McCarthy (1999) reported that berries start to lose weight due to water loss consequently, sugars are concentrated. These are explained with two possibilities. Firstly, grapes exhibit a prolonged water loss due to transpiration during advanced stages of ripening. Berries may shrivel but this period occurs in a short-term diurnal with no effect on the quality. (Bondada and Keller, 2012a). On the other hand, different irrigation regimes in a range of climates could be cause a reduction of osmotic potential in berry (Bondada and Keller, 2012b; McCarthy, 1997). Although the $\Psi_{md}$ values obtained from this study, which were tested under the same irrigation practices, showed close stress values, we found that the berries were shriveled in the overloaded vines. These vines may have triggered a stress mechanism. Secondly, some studies show that the reason for shriveling in berries is the backflow from berries (‘Shiraz’ and ‘Chardonnay’) to the parent vine via the xylem (Tyerman et al., 2004). Because berries of several cultivars remain hydraulically connected to the parent vine (Bondada et al., 2005; Chatelet et al., 2008). However, Tillbrook and Tyerman (2008) stated that water loss would not occur because the cell viability is preserved in cv. Thompson Seedless berries. This could be prevented with xylem tension also the osmotic potential of pericarp cell sap. They also stated that the changes in the pericarp of berries during the late-ripening process depend on the water balance in the berry. Our findings showed that there was no S berry in the treatment of 90 buds per vine, while it occurred in overloaded vines such as 150 buds and 180 buds per vine. In this case, it is hypothesized that vine yield also affects the water balance of berry which makes up the major component of berry mass. Water losses may occur in some berries when the crop load (cluster) increases.
Conclusion

We have here described a hypothesis for understanding the effect of excessive pruning levels (150 buds and 180 buds) on yield and the occurrence of shriveled berries of unhealthy clusters in the seedless grape cultivar. Although all treatments were tried under the same irrigation practices and determined close $\Psi_{m}$ stress levels, shriveled berries showing late-season dehydration symptoms could not be obtained at optimum pruning levels (90 buds per vine) and in both ratios of leaf removal treatments. Leaf removal treatments were performed only once (berry set time) at each pruning level in both years and could not show a great effect on shriveled berries but high pruning levels played an important role in obtaining shriveled berries. The water content of non-shriveled and shriveled berries was a key factor in the classification of basic berry maturity parameters like total soluble solids, titratable acidity, pH, and berry weight. Furthermore, a significant relationship between the numbers of harvested and unhealthy clusters was found in both years. Therefore, an increment of the number of clusters per vine may cause to obtain more unhealthy clusters and more shriveled berries on the lower side of these clusters.

Berry shrivel studies are generally carried out in wine grapes, the findings obtained in seedless grape cultivars may be different, therefore, we recommend that the berry shrivel studies should be conducted with excessive pruning levels per vine to identify the symptoms of water loss in berries easily in seedless cultivars. In this case, the relationship between shriveled berries and the water status of vines may be examined in detail before harvest in future studies.

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