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# CHANGES IN CERTAIN AGRONOMIC CHARACTERISTICS OF TABLE GRAPE CULTIVAR 'ALPHONSE LAVALLÉE' IN RESPONSE TO WATER DEFICIT UNDER THE DIFFERENT ROOTSTOCK EFFECT

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## *ABSTRACT*

The use of proper rootstocks for precision viticulture under increasing drought condition has a vital role, as the rootstocks vary in genetic response to various environmental stress factors. The present study was performed to investigate agronomic and growth responses of soilless grown four years old 'Alphonse Lavallée' vines to contrasting irrigation regime under the effect of different rootstocks. The study, conducted in glasshouse, was consisted of two irrigation levels [full irrigation (FI) and deficit irrigation (DI)] and two grafting combinations of the scion cultivar 'Alphonse Lavallée' with 41 B (*Vinifera* x *Berlandieri*) and 44-53 M (*Riparia* x *Rupestris*). The water holding capacity of soilless culture medium was used for to start FI, while fifty percent of FI was considered as DI. DI resulted in significant reductions in diameter and weight of the clusters of the scion grafted on both rootstocks with higher impact revealed in 41 B grafts. Generally, DI did not markedly impair the biochemical features of the must, except for the vines grafted on 41 B. Limitations in the leaf growth in response to DI were quite similar between the rootstocks. Pruning residue and vine yield reductions under DI were quite higher in vines grafted on 41 B than those of 44-53 M. In conclusion, 44-53 M seems more suitable for a water limited ecosystems on the condition that the lime stress is not a problem. Overall results revealed the differential response of the vines when grafted on different rootstocks.

**Contribution/Originality:** The paper's primary contribution is finding that reveals the importance of proper rootstock to alleviate the adverse effects of water deficit on grapevine growth for sustainable viticulture on the face of climate change.

## 1. INTRODUCTION

Sustainable methods to increase crop water productivity are gaining importance in arid and semiarid regions (Zsófi *et al.*, 2009) because the portion of fresh water currently available for agriculture is decreasing (Cai and Rosegrant, 2003). On the other hand, agricultural production will need to increase in order to sustain the rapidly growing world population. To match the food demands of increasing population, protected cultivation is increasing to use extra lands even under multiple stress factors. Although, the majority of crops in protected cultivation are grown in soil, there has been an increasing interest in the use of soilless culture techniques to overcome soil-specific problems. In Turkey, the soilless cultivation area increased from 10 ha in 1995 to 700 ha in 2012 (Tuzel and Oztekin, 2018).

Generally, agricultural studies have focused primarily on maximizing total crop production. However, in the recent years, focus has shifted to the limiting factors in agricultural production systems, notably the availability of water. Deficit irrigation (DI), in this context has been investigated as a valuable strategy for arid and semiarid regions (Fereres and Soriano, 2007). Understanding the physiological and agronomic bases of plant responses to mild or moderate water deficits is therefore of utmost importance to modulate the appropriate balance between vegetative and reproductive development in grapevines. Although the grapevine is one of a well-known drought avoidance species, the use of genetically drought tolerant rootstock and scion genotypes is the prime strategy. Grapevine rootstocks used over the world are generally hybrids of the north American species *Vitis berlandieri*, *V. riparia*, or *V. rupestris* to combat phylloxera damage or other biotic and abiotic stress factors (Serra *et al*., 2014). Because of high degree of genetic variability (Sabir *et al*., 2010) selection of accurate rootstock requires comprehensive considerations in every aspect of stress factors to ensure adequate productivity in sustainable ways. Literature review indicated that that selection of proper rootstocks under water-deficit conditions has vital role for a sustainable viticulture under drought conditions (Ezzahouani and Williams, 1995; Satisha *et al*., 2006; Sabir, 2016). The use of drought-tolerant rootstock would be welcomed as a large portion of vineyards around the world lacks suitable or adequate quantities or qualities of irrigation water. Previous studies demonstrated that rootstocks significantly modulate the response of the scion cultivar under various stress pressure (McCarthy *et al*., 2002; Sabir and Sari, 2019). Therefore, the main purpose of this study was to investigate agronomic and growth responses of soilless grown 'Alphonse Lavallée' vines to contrasting irrigation regime under the effect of different rootstocks 41 B and 44-53 M coming from different genetic origins.

## 2. MATERIALS AND METHOD

### *2.1. Study Layout*

The investigations were performed at the Research and Implementation Glasshouse (38°01.814 N, 032°30.546E, 1158m above sea level) of Selcuk University Agriculture Faculty in 2018. The three years old grapevines of table grape cultivar 'Alphonse Lavallée' was cultivated in 70 L (solid volume) pots filled with sterile peat and perlite mixture in equal volume. Just before the bud break, the experimental vines were spur pruned leaving 8 to 10 winter buds per plant. All the study vines received similar cultural practices and were drip irrigated using one irrigation line for per row, single emitter of 4 L $h^{-1}$ each per vine. The vines were placed in east-west oriented rows with the spaces 0.5 x 1 m (2000 plants per 1000 $m^2$). The study layout was a randomized complete block design with two irrigation levels [Full Irrigation (FI) and Deficit Irrigation (DI)] and two grafting combinations of the scion cv 'Alphonse Lavallée' with 41 B (*Vinifera* x *Berlandieri*) and 44-53 M (*Riparia* x *Rupestris*). The study vines, selected on the basis of homogeneity in vegetative growth, received the same annual amount of fertilizer (approx. 10 g N, 10 g P, 10 g K) from April to August. Irrigation treatments were replicated three times in randomized blocks, with two vines per replicate. The summer shoots were tied with thread to wires 2.3 m above the pots to let plants grow on a perpendicular position to ensure equally benefiting from the sunlight.

Irrigations were arranged according to soil water matric potential (Ψm) levels. Tensiometers (The Irrometer Company, Riverside, CA), placed at a depth of 20±2 cm and 12 cm away from the vine trunk, were continuously recorded from bud break (March) to the end of vegetation period (September) in order to control water level of growth medium. For adjustment of initial irrigation duration and amount, water holding capacity level of growth medium was first measured as described by Satisha *et al.* (2006). The calculated water holding capacity of soilless culture medium was used for start levels of full irrigation (FI) treatment while fifty percent of FI was considered as

DI (Sabir and Sahin, 2018) to perform mild drought stress. Tensiometers were employed for a long-term accurate tracking of substrate water depletion (Young and Sisson, 2002; Okamoto *et al.*, 2004).

### *2.2. Measurements*

The number and weight of clusters were obtained at harvest time (Bascunán-Godoy *et al.*, 2017). According to the norms of the Office International de la Vigne et du Vin (O.I.V, 1983) twelve clusters for each treatment were harvested when the vines attain at least 15.2 °Brix. The clusters were transported to the laboratory to investigate vine yield with cluster, berry and must features. For berry features, sixty berries per treatment were randomly collected from the middle of fifteen clusters to record the length, diameter and mass of the berry. Total soluble solid content was obtained using hand refractometer (Atago, Tokyo, Japan) in grape juice obtained by whisking the berries from each replication in a blender (1 min, 14 000 rpm) and then filtering the juice. Titratable acidity (TA) was determined by titrating 10 mL of juice using NaOH 0.1 mol $L^{-1}$ to pH 8.1 (AOAC, 1984). Results were expressed as g tartaric acid $L^{-1}$. At véraison stage, fully expanded healthy mature leaves of representative grapevines of each treatment (15 leaves per treatment) were collected to obtain leaf fresh dry mass values an analytical scale, with precision of 0.001 g. Pruning residue was measured after leaf drop in the following dormant season.

### *2.3. Statistical Analyses*

The collected data were subjected to statistical analysis. Statistical tests were performed at $P<0.05$ using SPSS 13.0 for Windows (SPSS Inc., Chicago, IL, USA), using the least significant difference (LSD) test.

## 3. RESULTS AND DISCUSSION

Cluster diameter and weight of 'Alphonse Lavallée' grapes showed significant variation in response to the treatment for both rootstock uses although cluster length did not significantly differ Table 1. In cluster diameter, 14.9% and 14.8% decreases occurred in response to DI when 'Alphonse Lavallée' scion cultivar was grafted on 41 B and 44-5 M, respectively. When 41 B rootstock was used, the cluster weight of DI (190.9 g) irrigation imposed grapevines was 24.5% lower than that of FI vines (237.8 g). On the other hand, 12.9% decrease in cluster weight was observed in response to the water deficit for the vines grafted on 44-53 M, changing from 226.4 g to 200.5 g. Under water deficit condition, it is well-known that remarkable reductions in plant carbon assimilation may occur due to decline in photosynthesis, as well as to a considerable loss of canopy leaf area (Maroco *et al.*, 2002). Affinity potential of scion and rootstock genotypes plays an essential role in carbon and nutrient transportation via floem and xylem vessels. Furthermore, understanding the scion/rootstock interaction is particularly important for ecosystems under stress factors in order to adjust water needs to the available resources. Careful consideration must be given not only to the total seasonal water available in a production region but also the timing when water deficits are likely to occur. Precision scheduling of irrigation practices would ensure well-balanced vegetative growth (Dokoozlian and Kliewer, 1996) and integrated management of diseases (Dry and Loveys, 1998).

**Table-1.** Changes in cluster features of 'Alphonse Lavallée' grape cultivar as influenced by irrigation treatments under the effect of different rootstocks.

| Rootstock | Treatment | Cluster length (mm) | Cluster diameter (mm) | Cluster weight (g) |
|---|---|---|---|---|
| 41 B | FI | 18.2±0.66 | 11.0±0.76a | 237.8±16.3a |
| | DI | 17.8±1.87 | 9.5±0.43b | 190.9±8.11b |
| 44-53 M | FI | 19.7±0.49 | 11.1±0.52a | 226.4±9.9a |
| | DI | 19.3±1.10 | 9.7±0.66b | 200.5±7.0b |

Means indicated by different letters identify significant difference (P<0.05, LSD).

As illustrated in Table 2, berry length, diameter and weight of 'Alphonse Lavallée' grapes showed significant variation in response to the treatment when 41 B was used. Berry length and diameter did not significantly differ in grapevines grafted on 44-53 M although there was significant difference in berry weight. Length, diameter and weight of the grape berry decreased by 4.8%, 3.9% and 8.6% in response to DI, when the scion cultivar was grafted on 41 B rootstock. There was also 4.2% decrease in berry weight for the vines grafted on 44-53 M, changing from 4.00 g to 3.84 g. DI will inevitably decrease source (leaves) to sink ratio below the optimum, resulting in berry quality losses. The intensity and timing of water shortage affect the extent of alterations occurring in berry metabolism and therefore in berry size or the synthesis. If water deficit is occurred early in the season, the effects will be achieved mostly through a reduction of berry cell division (McCarthy *et al.*, 2002). In many viticulture zones of Turkey, water deficit during early development stages of grape berries have been experienced, resulting the limitations in berry size.

**Table-2.** Changes in berry features of 'Alphonse Lavallée' grape cultivar as influenced by irrigation treatments under the effect of different rootstocks.

| Rootstock | Treatment | Berry length (mm) | Berry diameter (mm) | Berry weight (g) |
|---|---|---|---|---|
| 41 B | FI | 18.8±0.51a | 18.2±0.53a | 3.98±0.19a |
| | DI | 17.9±0.88b | 17.5±0.47b | 3.67±0.08b |
| 44-53 M | FI | 18.1±0.35 | 17.2±0.31 | 4.00±0.02a |
| | DI | 17.9±0.47 | 17.3±0.29 | 3.84±0.08b |

Means indicated by different letters identify significant difference (P<0.05, LSD).

Changes in grape total soluble solid content SSC, titratable acidity (TA) and pH values of 'Alphonse Lavallée' grape cultivar in response to irrigation treatments were indicated in Table 3. Almost all the features investigated were not affected by irrigation treatment, except for TA value of the grapevine grafted on 41 B. There was 8.1% increase due to water deficit in TA value of the must of the grape of 'Alphonse Lavallée' grafted on 41 B. Castellarin *et al.* (2007) observed no significant changes in sugar content of 'Merlot' wine grapes under water deficits, while they found a significant increase in sugar content in 'Cabernet Sauvignon' berries. The findings of present and the mentioned studies indicate that effects of water deficit on sugar content of grapevine berries are genotype-dependent. In certain studies, changes in titratable acidity were found insignificant in the must from moderately water-stressed vines (Matthews and Anderson, 1989; Esteban *et al.*, 1999). In fact, literature exhibits considerable variations regarding the biochemical changes in must of stressed vines due to multiple environmental variables between the regions.

**Table-3.** Changes in grape must features of 'Alphonse Lavallée' grape cultivar as influenced by irrigation treatments under the effect of different rootstocks.

| Rootstock | Treatment | SSC (°Brix) | Titratable acidity (g $L^{-1}$) | pH |
|---|---|---|---|---|
| 41 B | FI | 16.1±0.30 | 5.25±0.18b | 3.71±0.09 |
| | DI | 15.9±0.13 | 5.71±0.06a | 3.63±0.08 |
| 44-53 M | FI | 15.2±0.63 | 6.61±0.29 | 3.46±0.03 |
| | DI | 15.7±0.71 | 6.45±0.22 | 3.48±0.05 |

Means indicated by different letters identify significant difference (P<0.05, LSD).

As can be seen in Table 4, leaf fresh weight of the scion cultivar grafted on both rootstocks did not significantly change in response to DI. However, dry weight values exhibited significant decreases due to water limitation. DI resuted in 21.2% and 18.5% decreases in leaf dry weight values of the cultivar grafted on 41 B and 44-53 M rootstocks, respectively. Significant reductions in varying degrees depending on the response of the rootstocks to DI were also determined in pruning residue values. To illustrate, there were 27.3% and 20.9% decreases in pruning residue weight of the scion grafted on 41 B and 44-53 M respectively. Leaf morpho-anatomy and related development play a role in explaining plant adaptation to water stress (Aasamaa *et al.*, 2001). In general, plants develop an adaptation strategy to water deficit with a reduced leaf area to prevent excessive water loss from stomata.

**Table-4.** Changes in leaf and pruning residue weights of 'Alphonse Lavallée' grape cultivar as influenced by irrigation treatments under the effect of different rootstocks.

| Rootstock | Treatment | Leaf fresh weight (g) | Leaf dry weight (g) | Pruning residue (g) |
|---|---|---|---|---|
| 41 B | FI | 1.55±0.08 | 0.62±0.04a | 171.8±10.3a |
| | DI | 1.42±0.06 | 0.51±0.03b | 134.9±14.3b |
| 44-53 M | FI | 1.64±0.06 | 0.58±0.02a | 166.0±14.2 |
| | DI | 1.45±0.11 | 0.50±0.04b | 137.3±8.7 |

Means indicated by different letters identify significant difference (P<0.05, LSD).

As expected, DI led significant decreases in grape yield per vine Figure 1. Grape yield and reductions in response to water limitation were quite similar between the grafting combinations. Grape yield of 'Alphonse Lavallée' underwent 22.2% and 18.2% decreases due to DI treatment. These decrease percentages might be acceptable for grape growing under mild drought stress conditions. The constraints posed by global climate change necessitate adaptive management, namely irrigation to stabilize yield, maintaining or improving grape and quality. The combined effect of drought, high air temperature and high evaporative demand during hot summer in many areas limit yield and berry quality in grapevines (Costa *et al.*, 2007). The rootstocks used in this study slightly differed in modulation of the scion yield response to water deficit.

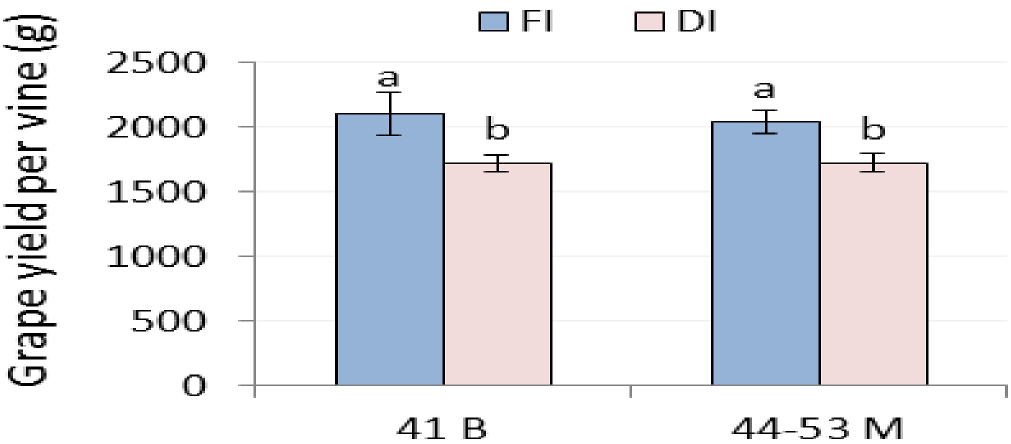


**Figure-1.** Changes in grape yield of 'Alphonse Lavallée' grape cultivar as influenced by irrigation treatments under the effect of different rootstocks.

## 4. CONCLUSION

DI did not significantly decrease the cluster length of 'Alphonse Lavallée' grafted on both rootstocks 41 B and 44-53 M although there were significant reductions in diameter and weight of the cluster. Decreases in berry size and weight due to water deficit showed obvious dependence on the rootstock use. DI led increase in titratable acidity of the grape must when 41 B was used, although the use of 44-53 M did not impair the biochemical features of the must. Limitations in the leaf growth in response to DI were also quite similar between the rootstocks used. Pruning residue and vine yield reductions to DI were quite higher in vines grafted on 41 B than those of 44-53 M. Therefore, 44-53 M seems more convenient for such a water limited ecosystems on the condition that the lime stress is not an important constraints. Overall results indicated the differential response of the vines when grafted on different rootstocks. Therefore, rootstock selection for a precision viticulture under stress factors is one of the most important issues for a sustainable grape growing. The resent study was conducted in soilless culture under protected cultivation techniques. Therefore the results are anticipated to guide for such production methods. The findings may also be adopted for intact viticulture techniques with careful assessment of environmental variables.

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