Effects of Different Methods of Pruning Intensity on Old Fig (Sabz Cultivar) Trees under Rainfed Conditions

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ABSTRACT
Old fig trees produce weak leaves, thin and short shoots, followed by low fruit quality under rainfed conditions. One of the strategies to confront with weak growth is severe pruning in rainfed fig trees. So far, the effect of different pruning methods on increasing tolerance has not been determined for rainfed fig trees. This experiment aimed to investigate the effects of different methods of severe pruning on the tolerance of fig trees to rainfed conditions, and their fruit quality and quantity as well. For this purpose, the experiment was conducted on complete randomized block design during three consecutive years. The results showed that the trunk thinning out along with the limb heading back pruning (with removal of ~75% wood) treatment not only had positive effects on the criteria for measurement of plant tolerance level to rainfed, but also had effective role in improving vegetative characteristics and also had significant effect on improving fruit attributes. Therefore, this treatment with the highest tolerance level to rainfed could be introduced as a good practice to preserve fig trees and produce relatively suitable fruit under severe droughts. On the other hand, the trunk thinning out together with green pruning (with removal of ~55% wood and foliage) was effective treatment on increasing yield and commercial quality such as increasing ostiole and fruit diameter, enhancing the number of early ripening fruits and fruit weight. Generally, the latter treatment enhanced production and fruit quality of old fig trees under rainfed conditions with suitable rainfall.

KEYWORDS
Fig tree; green pruning; limb heading back; trunk thinning out

Introduction

The fig (Ficus carica L.) is known as the most common fruit traded internationally. Dry figs are more common in Asia. In Iran, the annual dry fig production was estimated about 78000 tons. Iran is the fifth largest producer of figs in the world (FAO, 2017). ‘Sabz’ is a Smyrna-type cultivar usually do not produce Breba crop (first crop). Syconia of the Main crop (second crop) form and ripen only if pollinated. Sabz cultivar produced the most dried figs in Iran, and clarified to be the most drought tolerant under rainfed conditions compared with other cultivars (Sedaghat and Rahemi, 2018). Many branches of old fig trees (more than 50 years old) and about 10% of trees themselves were dried in successive droughts (Jafari et al., 2017).

Drought is the most significant abiotic stress limiting growth and threatening agricultural product (Cattivelli et al., 2008). There is a need for more consistent management tactics against this trouble. One tactic showing several advantages is cultural practices such as pruning method. If the tree canopy is severely pruned under rainfed conditions, the water requirement of the tree will be reduced and the soil can provide the adequate moisture for the plant until the water is recharged after rainfall.
Summer (green) pruning is an appropriate strategy for reducing drought damages in some trees. Summer pruning of apple tree increased canopy light transmission and light availability of interior leaves. Although summer pruning did not succeed to recover photosynthesis process of shaded leaves after re-exposure to light, it reduced canopy transpiration and water usage (Li, 2001). Removing leaves by summer pruning can be expected to reduce total water loss of canopy (transpiration), and consequently improve tree water status. In Washington State, heavy summer pruning has been used to help pear and peach orchards survive under severe drought seasons (Li et al., 2001).

Severe winter pruning has been reported as an appropriate strategy to confront with drought stress in some fruit trees (Jafari et al., 2017; Proebsting and Middleton, 1980; Worley and Mullinix, 1997). This type of pruning decreases leaf area and water demand in the growing season, resulting in tree survival under drought conditions. Severe pruning of peach and pear trees delayed drought symptoms until the end of the growing season, so all peach and pear trees with severe pruning tolerated drought well (Proebsting and Middleton, 1980). Although severe pruning of pecan trees reduced their yield, tree strength, shoot growth, fruit size, and percentage of standard fruit were increased (Worley and Mullinix, 1997).

Combination of severe pruning (severe thinning out of one-year-old lateral branches) and supplemental irrigation reduces relatively drought stress in rainfed figs (Abdolahipour et al., 2019); however, it is difficult to provide water for rainfed fig orchards. Severe pruning improved the vegetative characteristics of the fig tree by thinning all the trunks under rainfed and drought conditions, but the tree yield declined sharply. Two-trunk thinning pruning on a four-trunk tree had a positive effect on both tree and fruit attributes (Jafari et al., 2017).

Enough data have not been available on the different severe pruning effects about rainfed fig, yet. Therefore, this study aimed to investigate severe pruning methods on old fig trees due to drought stress reduction and fruit quantitative and qualitative enhancement.

**Materials and Methods**

**Experimental Site and Trees**

The experiment was conducted for three consecutive years in a mature ~50-year-old fig orchard (cv. 'Sabz'), spaced at 10 × 10 m (~100 trees ha⁻¹) and rainfed managed, located at the Fig Research Station, Estahban, Iran (29°08’ N, 54°02’ E, 1760 m altitude). Fig trees had been cultivated in the multiple trunks training method. The height and diameter of trees varied between 3.4 and 3.8 m and from 4.2 to 4.6 m, respectively. Although this subtropical climate have an average rainfall of ~273 mm, the large amount of which is received during December to April. Annual rainfalls were 262.4, 234.2, and 207.7 mm for the first to third experimental years, respectively (Table 1). The soil was a sandy loam texture and over 3 m deep. Caprification was carried out with Pouzdonbaly caprifig cultivar weekly from June 5th to July 5th for four times. The herbaceous plants were mechanically mowed between rows one time per year and beneath trees to reduce water loss one time manually per year. The orchard had received one-time pesticide sprays for mite controlling every year of experiment. However, it had received no mineral fertilization since its establishment. The homogeneity of the experimental trees was checked by measuring tree trunks circumferences before application of different treatments. Weather and meteorological data were prepared monthly by Estahban Meteorological Synoptic Station. Table 1

| Table 1. Estahban Meteorological data in the 3 experimental years. |
|---------------------------------------------------------------|
| **Temp. (°C)** | Relative humidity (%) |  |
| **Experiment Year** | Min. | Avg. | Max. | Min. | Avg. | Max. | Rainfall (mm) | Rainy days number | Maximum daily precipitation (mm) |
| First | −5.8 | 16.8 | 40.2 | 8 | 37 | 86 | 262.4 | 39 | 43.9 |
| Second | −5.6 | 17.3 | 40 | 10 | 40 | 77 | 234.2 | 44 | 41.3 |
| Third | −7.8 | 16.8 | 39.6 | 11 | 40 | 82 | 207.7 | 36 | 44.2 |
presents the basic information on air temperature, relative humidity, rainfall, rainy days number and maximum daily precipitation for the experimental years.

**Experimental Design and Treatments**

The experiment was carried out by following a randomized complete-block design with three replications in which two trees were considered as a replicate. The trees were randomly assigned along the blocks. The following eight pruning treatments included:

A control treatment (C), that traditional pruning (Figure 1a) was carried out. Traditional pruning was done by removing dried branches and a number of one-year lateral branches (about 1% wood) on all treatments in winter season.

Summer or green pruning (with removal of about 5% of the foliage) treatment (G), that was annually pruned syconium-less part (Figure 1b) of vigorous current season growth shoot in mid-July.

Limb heading back pruning treatment (H), pruned from middle length of 50% external limbs (with removal of ~25% wood) on external trunks (Figure 1c) in late winter of the first experimental year.

*Figure 1.* Pruning methods, a. Traditional pruning (Arrows indicate the location of pruned one-year lateral branches). b. Green pruning (The arrow indicates the location of the green pruning.). c. Limb heading back pruning (Arrows indicate the location of pruned limbs.). d. Trunk thinning out pruning (Arrows indicate the location of pruned trunkTSs.).
Limb heading back along with green pruning (with removal of ~30% of wood and foliage) treatment (HG), that G and H treatments were performed as the same as the previous two treatments. Trunk thinning out pruning treatment (T) that was pruned from 50% external trunks at ground level (with removal of ~50% wood) in late winter of the first experimental year (Figure 1d). Trunk thinning out along with green pruning (with removal of ~55% wood and foliage) treatment (TG), that G and T were pruned as before. Trunk thinning out along with limb heading back pruning (with removal of ~75% wood) treatment (TH), that T and H were pruned as before. Trunk thinning out together with limb heading back and green pruning (with removal of ~80% wood and foliage) treatment (THG), that T, H, and G were pruned as before.

Winter pruning was performed in March using saw and the pneumatic pruning device and also, wound places were covered with fungicide. Summer pruning of long current season growth shoot was carried out by bud pinching or shoot heading manually using garden scissors.

Measurements

Leaf temperature was measured with an infrared thermometer Testo 830-T2 Model. The thermometer was held so that the sensor viewed only the leaf at an oblique angle above the horizontal; this position gave an elliptical leaf target. All leaf temperature measurements were recorded in the south-facing direction, to minimize sun angle effects, and also measured between 12 and 13 P.M. (Nielsen and Anderson, 1989). Leaf width was measured from edge to edge at the widest part of fully developed leaves next to the third node. Leaf water potential was measured using a pressure chamber and a pressured nitrogen bottle (Boyer, 1967). The separated leaf was wrapped in a plastic bag to prevent transpiration, excise it. The leaf petiole was cut at the base using a scalpel. The leaf was placed in the chamber with the cut end of the petiole protruding through the seal. The leaf was sealed in the pressure chamber using the appropriate slitted gasket. Nitrogen gas was entered into the chamber until water appears at the cut end of the petiole. At this moment, the pressure was measured. The pressure is equal and opposite of the leaf water potential of the sample (Ψleaf) (Boyer, 1967).

To measure the total soluble solids (TSS), 1 g of fleshy tissue was picked from the neck of the fruit during commercial maturation and dissolved in 1 ml of distilled water and ground in a mortar. A drop of fruit juice was poured on refractometer (VBR 80S) screen and reading number was doubled (Sugiura et al., 1983). Fruit titrated acid (TA) was measured by titrating fig juice with 0.1 N of NaOH using phenolphthalein as an indicator (Samee et al., 2006). To express the fruit flavor index, the relationship between the ratio of soluble solids to the amount of titrated acid (TSS/TA) was used. Dry figs were evaluated by weighing and counting all fruits from each experimental tree during the harvesting period. Details of evaluated attributes are mentioned in Table 2.

Statistical Analysis

All data were analyzed separately and composed of three-year data using SAS software version 9.13. After statistical analysis, means comparison was carried out by Duncan’s multiple range tests.

Results

Leaf Parameters

Control treatment had the highest leaf temperature (36.17°C) and showed the significant difference with TH and THG treatments that had the lowest temperatures (31.37 and 31.93°C, respectively). Leaf water potential of TH (~1.04 MPa) and THG (~1.24 MPa) treatments were significantly a less negative compared with the C, G, and HG treatments (Table 3). TH treatment significantly changed both the leaf number in current season growth shoot and the leaf width that obtained the highest content,
Table 2. Details of evaluated attributes in the current study.

| Attributes               | unit     | equipment/method      | time interval | start and finish time |
|--------------------------|----------|-----------------------|---------------|-----------------------|
| Leaf temperature         | °C       | Infrared Thermometer  | weekly        | May – October         |
| Leaf width               | cm       | Ruler                 | weekly        | May – October         |
| Leaf number              | -        | Counting              | weekly        | May – December        |
| Leaf water potential     | MPa      | Pressure Chamber      | monthly       | May – October         |
| Shoot length             | cm       | Ruler                 | monthly       | May – October         |
| Shoot diameter           | mm       | Digital Calipers      | monthly       | May – October         |
| Shoot number             | -        | Counting              | yearly        | October               |
| Dried branches           | -        | Counting              | yearly        | October               |
| Syconia number           | -        | Counting              | yearly        | September             |
| Aborted syconia number   | number   | Counting              | yearly        | August                |
| TSS                      | °Brix    | Refractometer         | yearly        | September             |
| TA                       | %        | Titration             | yearly        | September             |
| Flavor                   | -        | Calculation           | yearly        | September             |
| Index                    |          |                       |               |                       |
| Fruit weight             | g        | Digital Scale         | yearly        | October               |
| Fruit skin color         | -        | Color catalog         | yearly        | October               |
| Ostiole condition        | -        | Observe               | yearly        | October               |
| Fruit size               | mm       | Fruit sorting         | yearly        | October               |
| Early ripe fruits number | number   | Counting              | yearly        | October               |
| Yield                    | g        | Digital Scale         | yearly        | October               |

The leaf area annually decreased in the C treatment whereas, pruned treatments enhanced it in a broad range (Figure 2). The THG treatment reduced the percentage of leaf abscission more than other treatments (Figure 3). The percentage of leaf abscission just decreased in G treatment compared with either C treatment or with other treatments (HG, TG, and THG) from August to November. The C treatment increased the rate of leaf abscission in each month. In other words, the earliest leaf abscission was observed in C treatment in comparison with other pruning treatments (Figure 3).

**Growth Rate of Shoot Length, Shoot Diameter, and Number**

The shoot annual growth indicated that the shoot length was enhanced by 36.56 and 26 cm in TH and THG treatments, respectively, that differed significantly with the C treatment and other treatments (Table 3). Pruning enhanced the shoot diameter in TH and THG treatments (9.44 and 8.72 mm) compared with the C treatment (Table 3). The changes of shoot number per tree revealed that the shoot number of TH and THG treatments was reduced compared to the C treatment in the first year after severe pruning but they produced new shoots rapidly in next years, therefore the number of their shoots were close to other treatments in following years (Figure 4). Branch drying of pruned and

Table 3. Effects of different severe pruning on the criteria for tolerance level measuring to drought (leaf water potential and temperature) and vegetative (leaf and shoot) characteristics of fig (Sabz cultivar) tree under rainfed conditions.

| Treatment | Leaf temperature (°C) | Leaf water potential (MPa) | Leaf number | Leaf width (cm) | Shoot length (cm) | Shoot diameter (mm) |
|-----------|-----------------------|----------------------------|-------------|-----------------|-------------------|---------------------|
| C         | 36.2 a*               | -1.5 a                     | 6.1 c       | 10.0 d          | 5.8 c             | 6.8 c               |
| G         | 35.3 a                | -1.5 a                     | 5.6 c       | 9.8 d           | 4.8 c             | 6.6 c               |
| H         | 35.2 a                | -1.4 ab                    | 6.4 c       | 10.9 c          | 6.0 c             | 6.9 c               |
| HG        | 35.4 a                | -1.6 a                     | 5.8 c       | 10.4 cd         | 5.4 c             | 6.8 c               |
| T         | 35.2 a                | -1.4 ab                    | 6.6 c       | 10.8 c          | 7.2 c             | 7.0 c               |
| TG        | 35.4 a                | -1.3 ab                    | 6.5 c       | 10.6 c          | 6.0 c             | 6.8 c               |
| TH        | 31.4 b                | -1.0 c                     | 15.2 a      | 13.3 a          | 36.6 a            | 9.4 a               |
| THG       | 31.9 b                | -1.2 b                     | 10.2 b      | 12.4 b          | 26.0 b            | 8.7 b               |

*In each column, the means with at least one same letter do not have a significant difference at the 5% level of Duncan’s multiple domains.
unpruned trees was low and nearly the same during three years of experiment particularly in years with suitable rainfall. However, some branches of unpruned tree died within years with under-normal precipitation. Increased vigor of pruning will allow new born branches to gradually develop (Data not shown).

**Syconia Number**

TH and THG treatments significantly increased syconia number on current season shoots from 3 to 10 syconium per shoot; however, the differences between other treatments were not significant (Table 4). C and some other treatments reduced syconia number resulted from fewer nodes per shoot (Table 4). Because of decreasing shoot number per tree, the number of syconia in TH and
Treatments were reduced after severe pruning compared with C treatment in the first year of experiment, however, they rapidly produced new shoots in the next years; therefore, their syconia number were close to other treatments in next years (Figure 5). Syconia formation in C and G treatments annually reduced, while syconia formation in other treatments increased at different rate. So high rate of syconia formation was obtained in the TH and THG treatments during three-year experiment. G treatment reduced syconia number in following years due to annual removing some of them (Figure 5). Although in the TH and THG treatments, 225 and 70 of the syconia

| Treatment | Syconia drop per tree | Syconia number per shoot | TSS (°Brix) | TA (%) | Flavor index |
|-----------|-----------------------|--------------------------|-------------|--------|--------------|
| C         | 938                   | 3.3                      | 14.0        | d      | 0.18         | a 78 a        |
| G         | 1169                  | 3.2                      | 14.3        | d      | 0.18         | a 79 a        |
| H         | 751                   | 3.5                      | 15.4        | c      | 0.20         | a 77 a        |
| HG        | 864                   | 3.4                      | 15.8        | c      | 0.20         | a 79 a        |
| T         | 920                   | 3.6                      | 17.0        | b      | 0.22         | a 77 a        |
| TG        | 985                   | 3.8                      | 17.3        | b      | 0.22         | a 79 a        |
| TH        | 70                    | 9.8                      | 18.5        | a      | 0.24         | a 77 a        |
| THG       | 225                   | 5.2                      | 18.9        | a      | 0.24         | a 79 a        |

*In each column, the means with at least one same letter do not have a significant difference at the 5% level of Duncan's multiple domains.

THG treatments were reduced after severe pruning compared with C treatment in the first year of experiment, however, they rapidly produced new shoots in the next years; therefore, their syconia number were close to other treatments in next years (Figure 5). Syconia formation in C and G treatments annually reduced, while syconia formation in other treatments increased at different rate. So high rate of syconia formation was obtained in the TH and THG treatments during three-year experiment. G treatment reduced syconia number in following years due to annual removing some of them (Figure 5). Although in the TH and THG treatments, 225 and 70 of the syconia
were just aborted per tree, respectively, in July; aborted syconia in other treatments was significantly higher (Table 4).

**Fruit Biochemical Properties**

Fig TSS content ranged from 14.0 to 18.9 °Brix at commercial maturity stage. TSS of fruits increased with the increased level of pruning as figs picked from the C treatment trees had a lower value. The TA content ranged from 0.18 to 0.24%, but fig TA was not significantly affected by pruning severity. Flavor index values of fig fruit varied from 77 to 79 at commercial maturity stage, but it was not influenced by pruning level (Table 4).

**Fruit Ripening Time**

Figs were classified into four groups: very early ripe, early ripe, middle ripe, and late ripe, depending on the time of their ripening. The percentage of ripe fruits in the first half of the September (early ripe) were increased in G, T, and TG treatments compared to C treatment, whilst fruits ripened in August.
Table 6. Effects of various pruning treatments on commercial quality of dried figs (Sabz cultivar) tree under rainfed conditions.

| Treatment | Fruit with closed ostiole (%) | Fruit with semi-open ostiole (%) | Fruit with open ostiole (%) | Fruits with dark brown skin (%) | Fruits with brown skin (%) | Fruits with yellowish skin (%) | Fruits with a diameter less than 17 mm (%) | Fruits with diameters between 17 and 23 mm (%) | Fruits with a diameter of more than 23 mm (%) |
|-----------|--------------------------------|----------------------------------|-----------------------------|-------------------------------|--------------------------|-------------------------------|------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| C         | 71.1                           | bc                              | 21.7                       | 7.3                           | ab                       | 28.3                         | a                                        | 61.1                                          | ab                                            |
| G         | 68.6                           | cd                              | 22.5                       | 8.9                           | a                        | 26.4                         | a                                        | 63.2                                          | a                                             |
| H         | 83.5                           | a                               | 14.1                       | 2.4                           | c                        | 29.7                         | a                                        | 60.1                                          | ab                                            |
| HG        | 71.9                           | bcd                             | 22.6                       | 5.5                           | abc                      | 27.1                         | a                                        | 59.9                                          | ab                                            |
| T         | 69.6                           | bcd                             | 22.8                       | 7.7                           | ab                       | 27.7                         | a                                        | 56.9                                          | ab                                            |
| TG        | 65.1                           | d                               | 25.4                       | 9.5                           | a                        | 23.2                         | a                                        | 63.6                                          | a                                             |
| TH        | 79.8                           | ab                              | 16.4                       | 3.8                           | bc                       | 28.2                         | a                                        | 48.6                                          | c                                             |
| THG       | 78.3                           | abc                             | 14.0                       | 6.3                           | abc                      | 30.7                         | a                                        | 53.0                                          | bc                                            |

*In each column, the means with at least one same letter do not have a significant difference at the 5% level of Duncan’s multiple domains.

Table 7. Effects of different severe pruning treatments on single dried fig weight and yield of Sabz cultivar under rainfed conditions.

| Treatment | Single dried fig weight (g) | Yield (g) |
|-----------|-----------------------------|-----------|
| C         | 4.0                         | b*        | 5670      | bc                              |
| G         | 4.0                         | b         | 7569      | ab                              |
| H         | 3.9                         | b         | 9912      | a                               |
| HG        | 4.2                         | ab        | 8720      | a                               |
| T         | 4.5                         | a         | 8062      | ab                              |
| TG        | 4.5                         | a         | 9776      | a                               |
| TH        | 4.5                         | a         | 4036      | cd                               |
| THG       | 4.2                         | ab        | 2711      | d                               |

*In each column, the means with at least one same letter do not have a significant difference at the 5% level of Duncan’s multiple domains.

(very early ripe), second half of the September (middle ripe) and in October (late ripe), the percentage was not significant (Table 5).

Commercial Quality of Dried Figs

Fig traders price dried fruits according to three quality features. The ostiole condition, color, and size of the dried fruits are assessed at the time of purchase. In terms of ostiole, the fruit has three modes of open, semi-open, and closed, which open ostiole are more valuable in the Sabz cultivar. As shown in Table 6, it was determined that the fruit percentage of open ostiole in G and TG treatments were significantly higher than in H and TH treatments (Table 6). TG treatment obtained the highest percentage of opened and semi-opened ostiole fruit and the lowest closed ostiole one (Table 6). Yellow, brown, and dark brown are the colors of dried figs, so yellow fruits have higher quality. The percentage of dried fruits with yellow color increased significantly in TH treatment (23.18%), whilst the percentage of dried fruits with brown skin color decreased in that treatment, (48.60%) compared with control treatment. If the skin color of dried fig fruit is yellow, it is commercially better than brown (Table 6). To determine fruit size, dried figs are graded into three groups depending on their diameter; above 23 mm, between 17 and 23 mm, and less than 17 mm. In this study, HG, T, and TG treatments had significantly a higher percentage of fruits with a diameter of 23 mm than G, H, and THG treatments (Table 6).

Single Dried Fig Weight and Yield

The weight of single fruit significantly increased in T (4.50 g), TG (4.54 g) and TH (4.47 g) treatments compared to C, G, and H treatments (Table 7). The yield of H, HG, and TG treatments with the values
of 9912, 8720, and 9776 g in the tree, respectively, were significantly different from C, TH, and THG treatments (Table 7).

**Discussion**

Drought in sub-tropical conditions is intensified by the higher temperature and resulted in an enhancement of leaf temperature. The increase in leaf or canopy temperature to detect plant water stress under drought condition was carried out by thermal sensing methods (Raschke, 1960), based on the developed infrared thermometers (Jackson, 1982; Jones, 2004; Jones and Leinonen, 2003). Water stress closes the stomata in plants, leading to increased leaf temperatures. Therefore, the increase in leaf temperature to some extent indicates the level of water stress in the plant. In this experiment, it was found that C to TG treatments had significantly higher temperatures than both TH and THG treatments. C to TG treatments were treatments that removed 1 to 55% of their wood and foliage with pruning, but there were still signs of water stress. While the TH and THG treatments with 75 and 80% removal of wood and foliage, respectively, during severe pruning, showed a significant decrease in leaf temperature, and therefore no sign of water stress was observed. This result was consistent with previous findings on peaches and pears (Proebsting and Middleton, 1980) and pecan (Worley and Mullinix, 1997). Reduced foliage and consequently higher transpiration per unit of canopy in TH and THG could be the reason for lower temperature in these treatments. The leaf temperature is a physiological parameter that can reflect the water status in many plants (Jiménez-Bello et al., 2011). According to our results, TH and THG showed the less negative of leaf water potential of all. Probably, the more parenchymal tissues resulting from the pruning increase leaf power in accumulation of water in the new shoot (Abdolahipour et al., 2019).

The current study showed that TH treatment was successful in increasing the leaf number and width. Although this treatment produced less leaf area per tree in the first and second year after applying severe pruning, it had almost as the same as the control levels in the next years. The reduced canopy volume was the indicator of less loss of tree water through the leaves after pruning. In a pilot study, it was found that tree water status for leaf expansion, expressed in mid-day leaf water potential, improved after pruning. The severe pruning decreased leaf temperature resulting in the positive effect on enhancement of photosynthetic rate during warm hours. Therefore, high leaf temperature of the control treatment might have raised respiration under water stress throughout the summer. In line with our result, the previous work on grapevines was observed that high leaf temperatures prevent higher rates of carbon assimilation (Weyand and Schultz, 2015). Leaf abscission normally began in July and prolonged until December in fig trees. Pruning treatments postponed leaf abscission time and changed its rate. In this study, it was found that severe pruning made remain the most leaves on shoot until mid-November; therefore, it increased both growth period and carbohydrates synthesis. Although it was possible that late leaf abscission was faced with early autumn chilling, no chilling symptoms were observed during three experimental years. It seemed that the chief objective of most G treatments retard the senescence, a process which was under hormonal control (Saure, 1987).

Heading back pruning led to an increase in the length of new shoots as reported by Sharma et al. (2018) in apple. Increase in diameter of shoots with an increase in severity of pruning in fig tree was observed compared with unpruned trees which was in line with the results obtained by Sharma et al. (2018). Radial growth of stem is an indicator of plant health and growing conditions (Daudet et al., 2005). Water stress-induced reduction of stem radial growth (Kozlowski, 1971) and clearly occurred in the C treatment.

The severe pruning annually developed great shoot vigor with appropriate length and diameter of shoot that reduced sunburn damages on both branches and trunks with their shading effect. The shoot number per tree was reduced after applying the severe pruning in the first year, but it was satisfied with high rate of new shoots in the next years. The rate of new shoot production was decreased in control treatment through dieback and declining of branches; however, the rate of it
was increased annually in severe pruning treatments. Winter thinning out along with heading back produced syconia more than other treatments in each shoot. Nevertheless, the syconia per tree were less than in control treatment in the first year of severe pruning; it was made up in later years. In addition, winter thinning out along with heading back had aborted syconia less than control. Weak branches and a great number of syconia per tree in control treatment led to syconia abortion. Since the rainfall of the study area was low, variable, and usually below 400 mm per year, results indicated that pruning improved the water status of trees. Not only did severe pruning reduce the maintenance of respiration, but also, results in a sink reduction for water consumption and dry matter allocation. Also, the highest photosynthetic rates were recorded in severely pruned trees (Elfadl and Luukkanen, 2003).

Under severe water stress conditions, many syconia were aborted and intensified under rainfed conditions in the summer. These syconia were aborted regardless of their caprifcation date. Perhaps early-formed syconia induced the abortion of later-formed syconia under water stress conditions. Our results indicate that limb pruning treatments (TH and THG treatments) reduced syconia drop, which was consistent with previous experiments that showed that pecan pruning increased the growth of the remaining limbs and thus increased fruit set and reduced fruit drop (Crane, 1933; Crane and Dodge, 1935; Sparks, 1988).

An increasing trend in total soluble solids was observed with increasing levels of pruning in figs, which was consistent with the results of pruning intensity on Poona cultivar fig and guava trees (Adhikari and Kandel, 2015; Chaudhari and Desai, 1996). The titratable acidity contents were similar to the reports of Silva et al. (2019), who found that TA contents ranged from 0.20% to 0.23% when the trees were pruned (Silva et al., 2019). Early ripening fruits have two benefits. First, the harvest of fruits is not affected by adverse weather conditions at the end of the season, such as early autumn rainfall. Second, with earlier harvest, the drought stress level decreases, that the most percentage of early ripened fruits was observed in G, T, and TG treatments. Contrary to the results of the heavy pruning experiment on Indian jujube, which delayed fruit maturity (Meghwal et al., 2017), severe pruning treatments on Sabz fig cultivar caused early fruit ripening compared to control trees, which was consistent with pruning results on Masui Daiphone fig variety (Hosomi et al., 2015).

Dry fig fruits are priced commercially with their skin color, size, and ostiole condition, so these three indicia were evaluated in the current study. If the skin color of dried fig fruit is bright yellow, it has commercially better quality than brown color and is commonly used for marketing and export. The first class fig was identified by fruit brighter color, bringing about better marketing (Sedaghat and Rahemi, 2018), which was in line with our study that by counting fruits with yellow, brown, and dark brown color, it was determined that the percentage of dried fruits with bright yellow color increased significantly in TH treatment. The highest percentage of open-ostiole fruits was observed in TG treatment. Contrary to high relative humidity sites, the relative humidity of Estahban fig orchard is about 30%; hence, the fruit’s opening causes the fruit to dry quickly and maintains its superior quality. For this reason, opened ostiole fruits have a higher commercial value than those with closed ostiole and can be accounted for an index of trade grade of fig. T and TG treatments played an important role in increasing the size of dried figs. Dried fig size is the major factor in marketing especially for direct consumption (Irget et al., 2008). Some severe pruning treatments on figs increased fruit weight compared to control, which was consistent with the results of apple pruning intensities (Choudhary and Dhakare, 2018). H, HG and TG treatments in this experiment increased the short-term (three-year) yield of fig trees. The reduction of total transpiration through severe winter pruning led to lower water consumption of the plant and lesser negative in the leaf water potential, which was associated with higher yields (Abdolalihipour et al., 2019). TH and THG showed the lowest yield, that its reduction by severe pruning in the early years of the study was inevitable, due to removal of large bearing limbs and trunks. Decreased yield of the first 3 years of study in very severe pruning treatments (TH and THG treatments) of the fig corresponded to a decrease in severe pruning performance of the limbs in pecan (Worley and Mullinix, 1997). Severe pruning of the selective limb did not influence the pecan
yield (Worley, 1991), however, in this experiment, some limbs pruning treatments (H and HG treatments) increased and in others (TH and THG treatments) decreased the yield compared to control trees.

**Conclusion**

As fig producers are supposed to consider the long-term beneficial effects of severe pruning, thus, during the 3 years of experiments, remarkable improvement was observed in growth and visual appearance of many severe pruned trees. The results of the present study indicated that thinning out along with heading back winter pruning treatment was the best strategy for reducing drought damages in fig orchard under rainfed conditions due to superiority in vegetative characteristics, less negative leaf water potential, reduced leaf temperature, and syconia drop, increased syconia number in the shoot, increase in soluble solids, fruit color, and weight quality. If short-term (three-year) profitability is considered, TG treatment is recommended due to increased yield, increase in commercial quality in terms of ostiole and fruit diameter, increase in the number of early ripening fruits, and increase in fruit weight. But under severe droughts, TH treatment is the best strategy to protect rainfed fig trees by pruning. In this treatment, by reducing the canopy, the water demand of the plant for transpiration is greatly reduced. This may have the following two consequences: a) the amount of soil water should be reduced much more slowly during the drought following severe pruning, and b) water requirement of regenerating shoot will be prepared from a much larger root system per unit leaf area. Both of these consequences should lead to better hydration for a regenerative branch during a severe drought. How long these effects of severe pruning persist are likely to depend on the local climate conditions, the percentage and direction of the orchard slope, soil and orchard management.

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