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# Response of Cherry Tomato to Irrigation Levels and Fruit Pruning under Greenhouse Conditions

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## ABSTRACT

**A greenhouse study was conducted to evaluate the response of cherry tomato cultivar Dulcito RZ to different irrigation levels and fruit pruning treatments. Treatments were three irrigation levels [50, 75, and 100%, based on the crop Evapotranspiration (ETc)], and three fruit pruning treatments (6, 8, and 10 fruits truss$^{-1}$). Results showed that the highest irrigation level (100% ETc) increased fruit weight and size, and total and marketable yield. However, water stress treatment (50% ETc) increased fruit quality traits (total soluble solids, titratable acidity, vitamin C, and total sugars). Plants pruned to 6 fruits truss$^{-1}$ yielded a heavier and larger fruit size, while unpruned plants had smaller fruit size with a significant increase in total and marketable yield due to increased number of fruits plant$^{-1}$. The increased incidence of fruit cracking with lower fruit load (6 fruits truss$^{-1}$) or with higher irrigation level (100% ETc) were related with the larger fruit size. The 50% *ETc* and full fruits truss$^{-1}$ (zero fruit pruning) treatments caused the highest values of irrigation water use efficiency (25.6-25.8 and 29.9-30.4 kg m$^{-3}$, respectively). To maximize marketable yield of cherry tomato and conserving irrigation water, it is recommended to apply 10 fruits truss$^{-1}$ pruning treatment along with the medium irrigation water level (75% ETc) under greenhouse conditions.**

**Keywords:** Fruit cracking, Irrigation water use efficiency, Marketable yield.

## INTRODUCTION

The interest in cherry tomato (*Lycopersicon esculentum* Mill. var. cerasiforme) has increased rapidly among many small farmers, special gardeners, and greenhouse managers throughout the world. It is characterized by higher productivity, superior quality, and better sweet taste than the large-fruit tomato (Kobryń and Hallmann, 2005; Menezes *et al*., 2012). Cherry tomato is becoming more attractive in super-markets with a high commercial value compared to the regular tomato (Menezes *et al*., 2012; Mantur *et al*., 2014).

Controlling number of flowers, fruits, or fruit trusses efficiently decrease inter fruit competition so that extra assimilates is diverted to lower number of fruits truss$^{-1}$. This practice leads to larger fruit size (Maboko and Du Plooy, 2008; Beckles, 2012). On the other hand, increasing fruit load of cherry tomato through pruning plants to two main branches permitted early fruit ripening and higher fruit yield over the single branch (Abdel-Razzak *et al*., 2013).

Irrigation water is becoming a limited resource in arid and semi-arid regions. Therefore, controlling water supply is a high priority (Pék *et al*., 2014). Crop water requirement is determined by evapotranspiration processes of the crop (ETc). In greenhouses, *ETc* is an important

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aspect for water management (Luvai *et al.*, 2014). Excessive irrigation can negatively affect fruit quality (total and soluble solids, and firmness) as well as encouraging the incidence of physiological disorders (i.e. cracking) and diseases due to high fruit water content (Peet and Willits, 1995; Dorais *et al.*, 2004). Application of optimal irrigation level is vital in increasing productivity and Irrigation Water Use Efficiency (IWUE) as well as maintaining fruit quality.

In order to improve yield productivity, fruit quality and *IWUE* of cherry tomato, it is necessary to assess pruning systems and amount of water supply. Therefore, the current study was undertaken to evaluate the response of cherry tomato plants to fruit pruning and irrigation level treatments under greenhouse conditions.

## MATERIALS AND METHODS

### Growth Conditions

Two experiments were carried out in greenhouse at the Agricultural Research and Experimental Station, Dirab region, near Riyadh, Saudi Arabia (24° 39' N, 46° 44' E) during 2011/2012 and 2012/2013 crop seasons. Seeds of cherry tomato (*Lycopersicon esculentum* cv. Dulcito RZ, RIJK ZWAAN; Netherlands) were germinated in Jiffy-7 peat pellets (Moerdijk, The Netherlands) on 5th September, 2011, and 9th September, 2012, under a controlled environment (25±1ºC day/18±1ºC night temperature). Uniform 30-days old seedlings were transplanted into the soil and grown in a controlled fiberglass greenhouse. Seedlings were transplanted along the edge of the furrow side with row spacing of 1.0 m and interplant spacing of 0.5 m. The soil was sandy with a texture of 82% sand, 9% silt and 9% clay, and with average pH= 7.8 and *EC* 1.72 dS $m^{-1}$. Average daytime temperature inside the greenhouse was set to 26±2ºC, night-time temperature was 18±2ºC; and relative air humidity was 70±2% throughout tomato growing seasons. During the experimental period, other agricultural practices such as fertilization and pest control were managed as recommended for tomato production (Maynard and Hochmuth, 2007).

### Experimental Treatments

#### a) Irrigation Water Levels

Cherry tomato plants were irrigated uniformly in the first two weeks after transplanting to ensure suitable take-off of the transplants. Then, irrigation water treatments started using a drip irrigation system. Irrigation water had an Electrical Conductivity (EC) of 1.24 dS $m^{-1}$. The irrigation treatments comprised three water levels based on the crop Evapotranspiration (ETc) of tomato, as follows: (L1) 100% *ETc* (control treatment), (L2) 75% *ETc* (moderate irrigation level), and (L3) 50% *ETc* (water stress treatment).

To determine the quantity of irrigation water, daily evaporation values were obtained from the Class A pan placed inside the greenhouse. Estimation of the irrigation requirements was based on crop coefficient (Kc) according to the equation described by Allen *et al.* (1998):

$$Kc = ETc/ET_0$$

$$ETc = ET_0 \times K_C$$

Where, $ET_0$= Is the evaporation from Class A pan (mm); *Kc*= Crop coefficient (range between 0.4 and 1.1, depending on the growth stage), *ETc*= Is the maximum daily crop evapotranspiration (mm).

Total period of irrigation treatments was 6 months, and the quantities of water requirements through the growing season were 3,000, 2,250 and 1,500 $m^3$ $ha^{-1}$ for high, moderate and low irrigation water levels, respectively.

#### b) Pruning Systems

Based on fruits removal, three pruning systems were applied: 6 fruits $truss^{-1}$ (low fruit load), 8 and 10 fruits $truss^{-1}$, and unpruned plants (zero fruit pruning) as a





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control treatment. Plants were trained into two branches to establish the 'V' trellising form. To conserve two branches, the main stem was cut after appearance of the first true leaf, and then, the two lateral branches were left to grow. First trusses were detached from all plants in an early stage due to irregular fruit set (Heuvelink and Buiskool, 1995). Fruits were pruned when they were marble size (Maboko *et al*., 2011). All side branches were removed as they appeared and old leaves were detached up to the youngest turning truss. To support the plants, they were trained vertically with strings fixed to a plastic wire at 2.5 m above the ground surface.

**c) Data Recorded**

Sixty days after transplanting, fruit harvesting was started and continued twice a week. The fruits were manually picked up at light red maturity stage. After each harvest, the collected fruits were weighed, counted and classified based on their diameter into five groups: Very large (> 35 mm), large (30-35 mm), medium (25-30 mm), small (20-25 mm), and very small (< 20 mm) according to Maboko and Du Plooy (2008) grading. Total yield was estimated by the addition of all five fruit size groups. Marketable yield was determined using the firm ripe fruits of the large (30-35 mm), medium (25-30 mm) and small size (20-25 mm). The marketable and the total crop yield were expressed in t $ha^{-1}$. Fruits showing symptoms of cracking were separately counted to estimate fruit cracking percentage.

**d) Fruits' Physical and Chemical Quality Traits**

Thirty fruits per treatment were randomly taken, weighted and divided for quality analysis. Ten random fruits were used to determine physical quality traits (average value of fresh weight and diameter). The remaining 20 fruits were homogenized in a fruit blender for chemical quality traits analysis. The juice was filtered by a Whatman No. 4 filter paper and Total Soluble Solids (TSS) were determined using a digital refractometer (PR-101, ATAGO, Japan). Fruit content of vitamin C (mg 100 $g^{-1}$ fresh weight, as ascorbic acid) was measured via 2,6 dichlorophenol-indophenol dye titration method (Patanè *et al*., 2011). Titratable acidity (% citric acid equivalent) was determined by titration with 0.1N NaOH to pH 8.5 using 10 mL of juice. Total sugars were measured following AOAC (2000) procedure.

**e) Irrigation Water Use Efficiency (IWUE)**

*IWUE* was computed as the ratio of total yield (kg $ha^{-1}$) to the total amount of irrigation water ($m^3$ $ha^{-1}$) applied during the growing season (Kirnak and Kaya, 2004).

**f) Experimental Layout and Statistical Analysis**

The experimental design was split-plot arranged in a randomized complete blocks, with four replicates. Irrigation levels were managed in the main plots and fruit pruning systems were placed in the sub-plots. The sub-plot area was 8 m², which comprised of 16 plants. Data were subjected to analysis of variance using the SAS System for Windows Version 8.1 (SAS, 2008). A revised Least Significant Difference (LSD) test at the 0.05 level was applied to statistically significant means (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

### Fruit Weight, Fruit Size, and Total Yield

Fruit weight, fruit size, and total fruit yield of cherry tomato plants were reduced with decreasing the quantity of water applied during the crop season (Table 1). The lightest fruit weight and smallest fruit size were obtained under water stress treatment (50% ETc). For fruit weight trait, treatment L1 gave heavier fruits (18.1-18.2 g) in comparison with fruit weight values of L3





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**Table 1.** Main effect of irrigation water levels and fruit pruning on physical fruit traits and total fruit yield of cherry tomato plants in 2011/2012 and 2012/2013 seasons.[a]

| Fruit traits and Total yield | Average fruit weight (g) | | Fruit diameter (Size) (cm) | | Total fruit yield ($t\ h^{-1}$) | |
|---|---|---|---|---|---|---|
| Exp treatments | 2011/12 | 2012/13 | 2011/12 | 2012/13 | 2011/12 | 2012/13 |
| (a) Water levels | | | | | | |
| L1 (100% ETc) | 18.2 a | 18.1 a | 3.00 a | 2.98 a | 66.913 a | 68.622 a |
| L2 (75% ETc) | 17.3 b | 17.1 b | 2.81 b | 2.80 b | 60.400 b | 61.575 b |
| L3 (50% ETc) | 12.7 c | 12.9 c | 2.33 c | 2.20 c | 35.837 c | 36.164 c |
| (b) Fruit pruning | | | | | | |
| Full fruits truss$^{-1}$ | 13.2 d | 13.5 d | 2.31 d | 2.35 d | 60.926 a | 62.130 a |
| 10 fruits truss$^{-1}$ | 14.5 c | 14.7 c | 2.49 c | 2.48 c | 54.470 b | 55.571 b |
| 8 fruits truss$^{-1}$ | 15.8 b | 15.9 b | 2.59 b | 2.57 b | 47.091 c | 47.394 c |
| 6 fruits truss$^{-1}$ | 17.4 a | 17.0 a | 2.82 a | 2.78 a | 40.502 d | 39.896 d |

[a] Means, in each treatment group, followed by the same letters are not significantly different at *LSD* 0.05 level.

treatment (12.7-12.9 g). The reduction in fruit fresh weight of cherry tomato was mostly explained by decreased fruit water content (Gautier *et al*., 2005). This result was predictable, since ripe tomato fruit normally contains about 95% water by volume (Beckles, 2012). Total fruit yield was positively affected by the amount of applied water (Table 1). Water stress treatment (50% ETc) generally tended to produce the lowest value of the total yield. In general, yield of cherry tomato cultivar Dulcito RZ decreased with the reduction of water levels applied in the two seasons as indicated by Abdel-Razzak *et al*. (2013). This approves that cherry tomato is considered to be one of the greatest water demanding fruit vegetable crops (Chen *et al*., 2013).

Fruit weight and size were significantly higher in fruit pruned plants than unpruned plants. Plants pruned to 6 fruits truss$^{-1}$ yielded heavier fruits with larger size (Table 1). This result is in accordance with Maboko and Du Plooy (2009) who reported that higher fruit load plant$^{-1}$ resulted in a decrease in source: sink ratio which reduced fruit size. Fruit pruning for low load fruits results in more assimilates transport to fruits and, consequently, gives heavier and larger size fruits (Hesami *et al*., 2012). Average fruit fresh weight of cherry tomato cultivar Dulcito RZ ranged from 12.7 to 18.2 g, which is parallel with many other commercial varieties of cherry tomato. In another study, average fresh weight for both cherry tomato varieties Pizzaiolo and Sweet Million was 17 g fruit$^{-1}$ (Aguirre and Cabrera, 2012). Under greenhouse conditions, average fresh weight values of some commercial cherry tomato varieties ranged between 13.3 to 16.3 g fruit$^{-1}$ (Aguirre and Cabrera, 2012). On the other hand, unpruned plants gave higher total yield plant$^{-1}$ as a result of increased total number of fruits truss$^{-1}$ and weight of small fruits, as compared to the other fruit pruning treatments. The increment in the total number of fruits was responsible for the total yield increase, compensating for the decrease in fruit weight and size (Table 1). These responses might be due to greater quantity of fruits, larger expenditure of resources, and lower products of photo-assimilation (Franco *et al*., 2009).

## Fruit Chemical Quality

The highest significant values of fruit TSS, vitamin C, titratable acidity, and total sugars contents were found under the lowest water level (50% ETc), while the lowest values of fruit chemical quality traits were recorded with the highest water level (100% ETc) treatment (Table 2). These results have been confirmed by a previous study (Abdel-





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**Table 2.** Effect of irrigation water levels and fruit pruning on chemical quality traits of cherry tomato fruits in 2011/2012 and 2012/2013 seasons.[a]

| Growing seasons | First season 2011/2012 | | | | Second season 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|
| Fruit quality traits / Treatments | TSS (%) | Vitamin C (mg100 g$^{-1}$ fw) | Titratable Acidity (%) | Total Sugars (%) | TSS (%) | Vitamin C (mg 100 g$^{-1}$ fw) | Titratable Acidity (%) | Total Sugars (%) |
| (a) Water levels | | | | | | | | |
| L1 (100% ETc) | 7.2 c | 23.7 b | 0.55417 c | 6.43 c | 7.1 c | 23.2 c | 0.56833 b | 6.30 c |
| L2 (75% ETc) | 7.8 b | 23.9 b | 0.57833 b | 6.88 b | 7.6 b | 24.0 b | 0.57417 b | 6.74 b |
| L3 (50% ETc) | 9.0 a | 25.2 a | 0.60458 a | 8.01 a | 8.7 a | 25.5 a | 0.60791 a | 7.88 a |
| (b) Fruit pruning | | | | | | | | |
| Full fruits truss$^{-1}$ | 7.6 d | 23.7 c | 0.56417 d | 6.63 d | 7.4 d | 23.6 c | 0.56500 d | 6.51 d |
| 10 fruits truss$^{-1}$ | 8.0 c | 24.3 b | 0.57667 c | 7.19 c | 7.9 c | 24.4 b | 0.57750 c | 7.09 c |
| 8 fruits truss$^{-1}$ | 8.5 b | 24.6 b | 0.59416 b | 7.61 b | 8.3 b | 24.8 b | 0.60000 b | 7.43 b |
| 6 fruits truss$^{-1}$ | 8.9 a | 25.2 a | 0.60667 a | 7.88 a | 8.6 a | 25.3 a | 0.61583 a | 7.78 a |

[a] Means in each treatment group followed by the same letter are not significantly different at *LSD* 0.05 level.

Razzak *et al*., 2013) in which lower irrigation rate (40% ETc) improved fruit quality traits of cherry tomato Dulcito RZ cultivar. Patanè *et al*. (2011) pointed out that titratable acidity and vitamin C contents of processing tomato (cultivar Brigade) were improved under water stress treatment (50% ETc) as compared to a full irrigation water treatment (100% ETc).

Fruit chemical quality traits were significantly affected by fruit pruning systems. Fruit TSS, vitamin C, titratable acidity, and total sugars contents were increased by decreasing number of fruits truss$^{-1}$ (Table 2). Fruit pruning system of 6 fruits truss$^{-1}$ increased TSS, vitamin C, titratable acidity, and total sugars of fruit. As number of fruits increased, plants are forced to feed more fruits with reducing fruit weight and quality (Ece and Darakci, 2007). In general, the increase in fruit chemical quality aspects resulting from low fruit load pruning treatment can refer to more assimilates production diverted to fewer sinks (Hesami *et al*., 2012; Beckles, 2012).

## Marketable Yield

Small to medium size round fruit shape (20-30 mm diameter) of cherry tomato is the most popular type in the vegetable markets (Maboko and du Plooy, 2008). Therefore, the present study focused on total marketable yield of these two fruit size groups: small (20-25 mm) and medium (25-30 mm), in addition to large size fruits (30-35 mm) of cherry tomato Dulcito RZ cultivar (Table 3). The highest marketable yield (24.863-25.336 t ha$^{-1}$) of medium size fruit was obtained by the plants under moderate water level (75% ETc). Water stress treatment (50% ETc) produced the highest marketable yield (13.943-14.767 t ha$^{-1}$) of small fruit size. However, the highest water level (100% ETc) resulted in the highest marketable yield (27.959-28.686 t ha$^{-1}$) of large fruit size. On the other hand, the highest value of marketable yield was in

**Table 3.** Effect of irrigation water levels and fruit pruning on marketable yield of cherry tomato plants during 2011/2012 and 2012/2013 seasons.[a]

| Growing seasons | First season 2011/2012 | | | | Second season 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | Small size ($t\ h^{-1}$) | Medium size ($t\ h^{-1}$) | Large size ($t\ h^{-1}$) | Marketable yield ($t\ h^{-1}$) | Small size ($t\ h^{-1}$) | Medium size ($t\ h^{-1}$) | Large size ($t\ h^{-1}$) | Marketable yield ($t\ h^{-1}$) |
| (a) Water levels | | | | | | | | |
| L1 (100% ETc) | 9.378 c | 17.101 b | 28.686 a | 55.166 a | 11.183 b | 16.775 b | 27.959 a | 55.919 a |
| L2 (75% ETc) | 11.320 b | 25.336 a | 17.250 b | 53.907 a | 12.161 b | 24.863 a | 17.026 b | 54.051 a |
| L3 (50% ETc) | 13.943 a | 9.699 c | 6.668 c | 30.311 b | 14.767 a | 9.897 c | 6.755 c | 31.421 b |
| (b) Fruit pruning | | | | | | | | |
| Full fruits truss$^{-1}$ | 19.354 a | 17.511 b | 9.216 d | 46.083 a | 20.486 a | 17.935 b | 9.755 d | 48.176 a |
| 10 fruits truss$^{-1}$ | 11.613 b | 19.653 a | 13.400 c | 44.667 b | 11.574 b | 19.745 a | 14.071 c | 45.391 b |
| 8 fruits truss$^{-1}$ | 8.217 c | 16.845 b | 16.023 b | 41.087 c | 8.118 c | 16.860 b | 16.652 b | 41.631 c |
| 6 fruits truss$^{-1}$ | 5.265 d | 8.273 c | 24.069 a | 37.608 d | 5.552 d | 8.513 c | 22.948 a | 37.014 d |

[a] Means, in each treatment group, followed by the same letters are not significantly different at *LSD* 0.05 level.

the 100% *ETc* followed by 75% *ETc* treatment (Table 3). The improvement of marketable yield of Dulcito RZ cultivar, as water level increased, mainly resulted from the increase of average fruit weight and size (Table 1). These findings were supported by Pulvento *et al*. (2008). They found that the marketable yield enhancement of the two cherry tomato cultivars (Altavilla standard and Mignon hybrid) was correlated to irrigation water volume. Kuscu *et al*. (2014a) also reported that deficit irrigation strategies adversely affected marketable yield and fruit weight of processing tomato.

Marketable yield was increased significantly with an increase in fruit number truss$^{-1}$ due to the highest increase in yield of small and medium size fruits (Table 3). Marketable yield increased significantly in unpruned plants (control treatment), followed by pruning plants to 10, 8, and 6 fruits truss$^{-1}$. These results might be in harmony with the study of Maboko and du Plooy (2008) who found that marketable fruit yield of cherry tomato increased significantly with an increase in number of stems due to increased yield in small and medium sized fruits. The largest marketable yield of medium size fruits was obtained by pruning the Dulcito RZ plants to 10 fruits truss$^{-1}$. Unpruned plants produced the largest marketable yield of small fruit size. However, pruning the Dulcito RZ plants to 6 fruits truss$^{-1}$ gave the highest value of large fruit size (Table 3). That may be attributed to the low fruit load (6 fruit truss$^{-1}$) treatment. The lower total fruits number plant$^{-1}$ was partly compensated by a higher fruit weight and size, but resulted in a decrease in marketable yield as compared to the other pruning treatments (Tables 1 and 3). In general, the highest value of marketable yield was found in unpruned plants followed by plants pruned to 10 fruits truss$^{-1}$. This finding reflected that fruit number plant$^{-1}$ was responsible for increasing marketable yield more than fruit weight. Recent studies of Pék *et al*. (2014) and Szuvandzsiev *et al*. (2014) indicated that fruit number and average fresh weight had positive influence on marketable yield of cherry tomato Strombolino $F_1$ cultivar, but number of fruits showed higher positive correlation with the marketable yield than with average fruit weight.

## Fruit Cracking

Fruit cracking is a physiological disorder that affects tomato fruit quality (Peet, 2009). The symptoms of this phenomenon is occurrence of cracks on various areas of the proximal surface of fruit and results in decreased fruit attractiveness and low market value (Peet and Willits, 1995; Guichard *et al*., 2001).

At higher water level (100% ETc), higher percentage of fruit cracking (5.45-5.52%) was observed (Figure 1). Hence, water stress treatment (50% ETc) produced the lowest percentage of fruit cracking (0.93-1.17%). Peet (2009) reported that excess water in the greenhouse culture leads to increased fruit cracking. Further, Pék *et al.* (2014) stated that excess water supply increased fruit weight which caused fruit cracking of larger fruits. In another study, Szuvandzsiev *et al.* (2014) reported that higher water supply resulted in higher fruit yield but increased the non-marketable yield through a higher number of cracked fruit.

Fruit cracking incidences occurred under all fruit pruning systems. Higher percentage of fruit cracking (5.79-6.92%) was found in pruned plants with low fruit load (6 fruits truss$^{-1}$). Cracking decreased with increasing number of fruits truss$^{-1}$ (Figure 1). These results support the findings of Ehret *et al.* (1993) who found that with an increase of the leaf: fruit ratio through fruit thinning resulted in increased fruit size and fruit cracking.

## Irrigation Water Use Efficiency

Decreasing irrigation water levels positively affected *IWUE*. Water stress treatment (50% ETc) increased *IWUE* value by 14.80 and 3.64% over the 100 and 75% *ETc* water treatments, respectively, in 2011/2012 season, and by 12.66 and 6.61%, respectively, in 2012/2013 season (Figure 2). This result supports other studies for regular tomato (e.g. Kirnak and Kaya, 2004; Sezen *et al*., 2010; Patanè *et al*., 2011; Kuscu *et al*., 2014b). They concluded that tomato plants consumed water more efficiently at lower irrigation amounts than at higher water quantities.

The *IWUE* value in plants pruned to 6 fruits

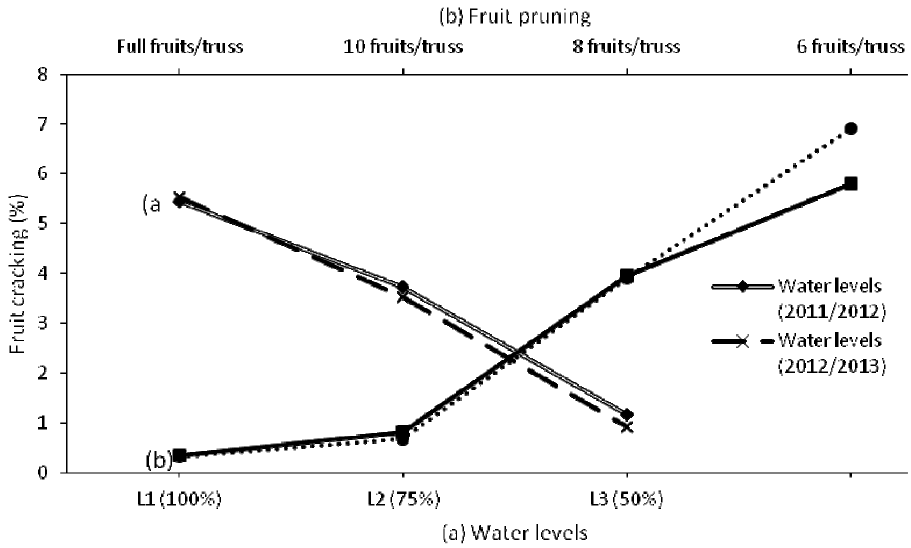



**Figure 1.** Effect of irrigation water levels (a) and fruit pruning treatments (b) on fruit cracking (%) of cherry tomato plants during the two seasons of 2011/2012 and 2012/2013.

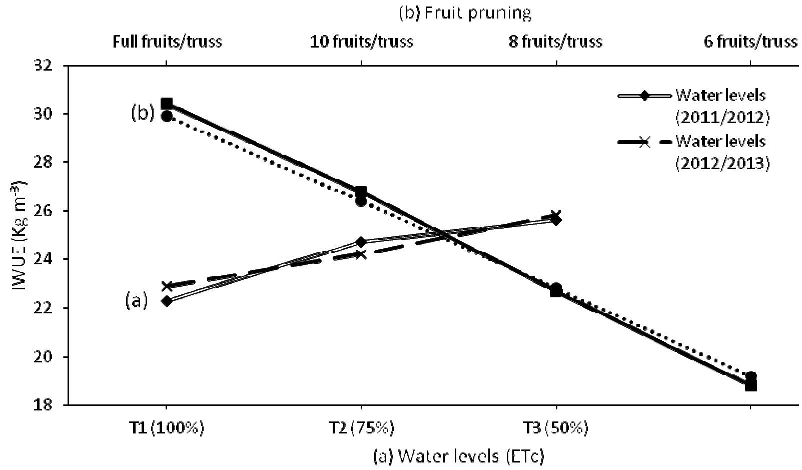



**Figure 2.** Effects of irrigation water levels (a) and fruit pruning treatments (b) on *IWUE* of cherry tomato plants during the two seasons of 2011/2012 and 2012/2013.

truss$^{-1}$ (low fruit load) significantly decreased as compared with those pruned to 8 or 10 fruits truss$^{-1}$ (Figure 2). Fruit pruning system for low fruit load (6 fruits truss$^{-1}$) reduced the total fruit yield (Table 1) and, consequently, decreased the *IWUE.* Unpruned plants (with higher fruit load) significantly increased *IWUE* value by 55.73-61.70% as compared to plants pruned to lower fruit load.

## Interaction Effect between Irrigation Water Levels and Fruit Pruning

Plants with 6 fruits truss$^{-1}$ and under 100% *ETc* treatment had the highest fruit weight and size. However, maximum marketable and total yield were found with unpruned plants under 100% *ETc* treatment (Table 4). This treatment produced the highest total yield (75.198-77.100 t h$^{-1}$), and marketable yield (60.535-60.608 t h$^{-1}$). The average value of total yields of 44.054-77.100 t h$^{-1}$ recorded in this study with different pruning systems under, respectively, 100% and 75% *ETc* irrigation water level treatments were in the same trend with values found in some commercial cherry tomato varieties like Brillantino, Marasca, Ovalino, Tamburino, and Sweet Million, whose production yields ranged between 54.27 and 87.73 t ha$^{-1}$ (Aguirre and Cabrera, 2012). On the other hand, lowest values of total yield (21.858-22.602 t h$^{-1}$) and marketable yield (16.279-18.006 t h$^{-1}$) were recorded in plants pruned to 6 fruits truss$^{-1}$ (low fruit load) under water stress treatment (50% ETc). This was mainly due to low fruit load with heavier weight and large fruits.

Moreover, the highest fruit quality (TSS and total sugars) values were found in plants pruned to 6 fruits truss$^{-1}$ under water stress treatment (50% ETc). These results were in accordance with Patanè *et al.* (2011). They reported that lower water supply provided low tomato marketable yield with high fruit quality traits. The sugar content is the principal trait of tomato fruit as high sugar content determines sweetness and is vital for best flavor for the consumer (Teka, 2013). Cherry tomato Dulcito RZ cultivar exhibited higher total sugars content (7.20-10.70%) than other cherry tomato cultivars. The sugar content value of 6.02% was reported in cherry tomato Favorita and Conchita cultivars (Kobryń and Hallmann, 2005) and 4.27-4.34% values were found in Altavilla and Mignon hybrid cultivars (Pulvento *et al.*, 2008). This quality trait makes cherry tomato Dulcito RZ fruits represent a proper source for either local or export vegetable markets in which consumers desire sweet tasting fruit.

Plants with 6 fruits truss$^{-1}$ irrigated with the highest water level (100% ETc) resulted in the highest value (10.00-11.67%) of fruit

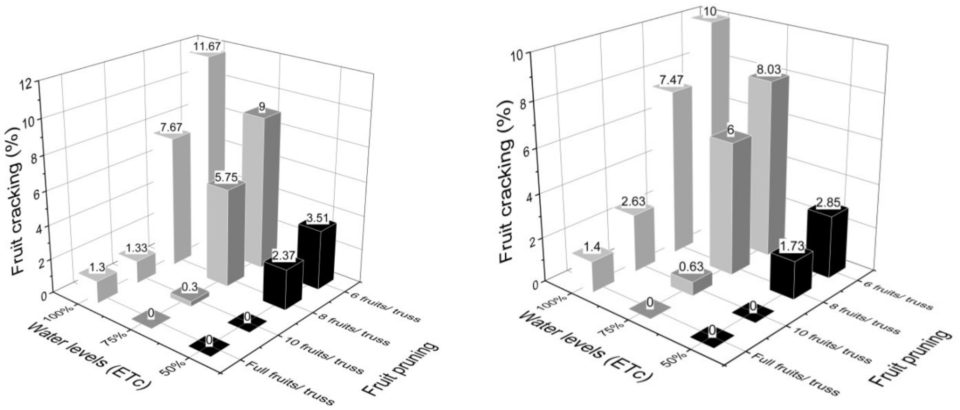
**Table 4.** Interaction effects of irrigation water levels and fruit pruning on fruit fresh weight, fruit size, marketable yield, total crop yield, TSS and total sugars of cherry tomato plants during 2011/2012 and 2012/2013 seasons.

| Experimental treatments | | First season 2011/2012 | | | | | | Second season 2012/2013 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Irrigation levels | Fruit pruning | Fruit fresh weight (g) | Fruit size (cm) | Marketable yield (t $h^{-1}$) | Total crop yield (t $h^{-1}$) | TSS (%) | Total sugars (%) | Fruit fresh weight (g) | Fruit size (cm) | Marketable yield (t $h^{-1}$) | Total crop yield (t $h^{-1}$) | TSS (%) | Total sugars (%) |
| 100% *ETc* | Zero pruning | 15.2 | 2.69 | 60.608 | 75.198 | 6.8 | 5.93 | 15.7 | 2.68 | 60.535 | 77.100 | 6.6 | 5.73 |
| | 10 fruit truss$^{-1}$ | 17.4 | 2.91 | 57.309 | 70.569 | 6.9 | 6.37 | 17.5 | 2.86 | 58.401 | 72.888 | 6.9 | 6.27 |
| | 8 fruit truss$^{-1}$ | 18.6 | 3.00 | 53.028 | 62.462 | 7.3 | 6.67 | 18.7 | 2.98 | 53.141 | 64.234 | 7.2 | 6.47 |
| | 6 fruit truss$^{-1}$ | 21.4 | 3.42 | 55.719 | 59.423 | 7.9 | 6.73 | 20.9 | 3.39 | 55.601 | 60.267 | 7.6 | 6.73 |
| 75% *ETc* | Zero pruning | 15.1 | 2.63 | 59.730 | 73.287 | 7.1 | 6.33 | 15.4 | 2.63 | 60.286 | 75.850 | 6.9 | 6.17 |
| | 10 fruit truss$^{-1}$ | 16.2 | 2.76 | 57.839 | 66.178 | 7.7 | 6.67 | 16.5 | 2.75 | 57.591 | 68.267 | 7.5 | 6.57 |
| | 8 fruit truss$^{-1}$ | 18.3 | 2.80 | 52.612 | 55.635 | 8.0 | 7.03 | 17.8 | 2.82 | 54.274 | 57.033 | 7.8 | 6.87 |
| | 6 fruit truss$^{-1}$ | 19.5 | 3.07 | 45.449 | 46.503 | 8.3 | 7.47 | 18.7 | 2.98 | 44.054 | 45.150 | 8.1 | 7.37 |
| 50% *ETc* | Zero pruning | 11.2 | 2.56 | 34.996 | 47.610 | 8.2 | 7.13 | 11.5 | 2.04 | 39.143 | 47.785 | 8.0 | 7.06 |
| | 10 fruit truss$^{-1}$ | 12.1 | 2.14 | 31.760 | 40.566 | 8.7 | 7.87 | 12.4 | 2.15 | 32.786 | 40.564 | 8.5 | 7.77 |
| | 8 fruit truss$^{-1}$ | 13.1 | 2.23 | 29.354 | 35.134 | 9.4 | 8.67 | 13.4 | 2.25 | 29.554 | 34.154 | 9.1 | 8.18 |
| | 6 fruit truss$^{-1}$ | 14.2 | 2.09 | 24.632 | 28.040 | 9.9 | 9.47 | 14.2 | 2.37 | 24.200 | 27.083 | 9.3 | 8.51 |
| *LSD* at 0.05 | | 0.124 | 0.026 | 0.241 | 0.219 | 0.381 | 0.139 | 0.186 | 0.023 | 0.274 | 0.249 | 0.296 | 0.189 |

cracking (Figure 3). Therefore, larger fruits resulting from the lowest fruit loads plant$^{-1}$ under the highest water supply might be responsible for high fruit cracking. Ohta *et al*. (1997) reported that fruit cracking in cherry tomato starts as a result of increasing fruit size which is initiated by a rapid solute inflow into the fruits. The interactive effect of irrigation level and fruit pruning system showed significant effect on *IWUE* values. In general, *IWUE* of the various irrigation treatments tended to increase under the lowest water level (50% ETc), mainly with unpruned plants (zero fruit pruning), as compared with other treatments (Figure 4). This result agrees with the previous findings of Abdel-Razzak *et al*. (2013) in which the highest *WUE* value of cherry tomato was obtained in plants pruned to two branches under water stress treatment.

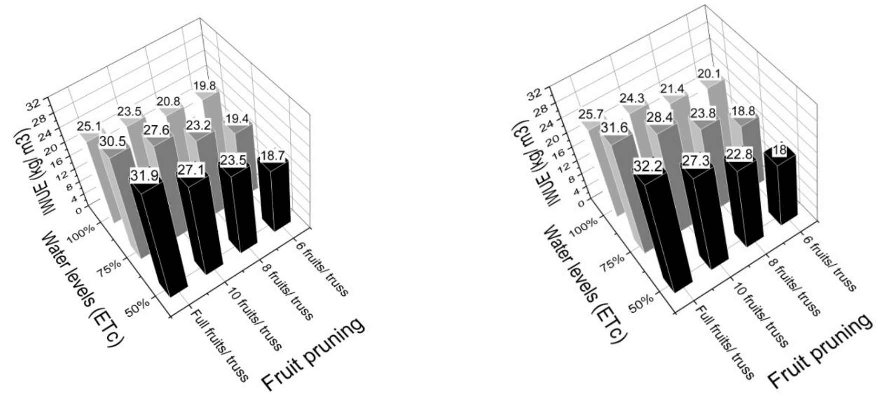
## CONCLUSSIONS

Cultural practices such as fruit pruning and irrigation managements can have a major influence on plant growth, yield, and fruit quality traits. For cherry tomato, the fruit weight, size, and total and marketable yields increased with 100% *ETc* irrigation level. However, fruit quality traits increased at water stress treatment (50% ETc). Moderate water level (75% ETc) could be considered as it saves 25% of irrigation water with no significant reduction in marketable fruit yield. Among the fruit




(a) First season (2011/2012) (b) Second season (2012/2013)

**Figure 3.** Interaction effects of irrigation levels×fruit pruning treatments on fruit cracking (%) of cherry tomato plants during the two seasons (a and b).




(a) First season (2011/2012) (b) Second season (2012/2013)

**Figure 4.** Interaction effects of irrigation levels x fruit pruning treatments on *IWUE* of cherry tomato plants during the two seasons (a and b).

pruning treatments applied in this study, fruit pruning to 10 fruits truss$^{-1}$ was the best pruning system to increase marketable yield. It can be concluded that fruit pruning system for 10 fruits truss$^{-1}$ combined with the medium irrigation water level (75% of ETc) is recommendable for cherry tomato production under greenhouse conditions for high marketable yield, fruit quality, and better saving of irrigation water.

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# واکنش گوجه فرنگی گیلاسی به مقادیر آبیاری و هرس میوه در شرایط گلخانه

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## چکیده

هدف این آزمایش گلخانه ای ارزیابی واکنش گوجه فرنگی گیلاسی کولتیوار Dulcito RZ به مقادیر آبیاری و هرس میوه بود. تیمار ها عبارت بودند از سه سطح آبیاری (۵۰٪، ۷۵٪، و ۱۰۰٪ تبخیرو تعرق گیاه، ETc) و سه تیمار هرس میوه (۶، ۸، و ۱۰ میوه در هر خوشه گل(truss).نتایج نشان داد که تیمار بیشترین سطح آبیاری(ETc٪۱۰۰) اندازه و وزن میوه ها و نیز عملکرد قابل فروش را زیاد کرد. با این وجود، تیمار تنش آبی( ETc٪۵۰) صفات کیفیتی میوه ( مواد جامد محلول، اسیدیته قابل سنجش، ویتامین C ، و قند کل) را بهبود بخشید. همچنین، بوته هایی که به ۶ میوه در هر گل شاخه هرس شده بودند میوه های درشت تر و سنگین تری داشتند در حالیکه در بوته های هرس نشده با وجود داشتن میوه های کوچکتر، به علت زیادتر بودن تعداد میوه، عملکرد کل و عملکرد قابل فروش به طور معنی داری بیشتر بود. وقوع ترک خوردگی بیشتردر میوه ها ی بوته هایی که میوه کمتری داشتند( ۶ میوه در هر گل شاخه) یا آب بیشتری دریافت کرده بودند( ETc٪۱۰۰) با بزرگتر بودن اندازه میوه ها رابطه داشت. تیمار ETc٪۵۰ و تیمار بدون هرس بالاترین مقدار کارآیی مصرف آب ( به ترتیب برابر۲۵/۸– ۲۵/۶ و ۳۰/۴–۲۹/۹ کیلو گرم در متر مکعب) را نشان دادند. به این قرار، برای بیشینه کردن عملکرد قابل فروش گوجه فرنگی گیلاسی و صرفه جویی در مصرف آب، توصیه می شود که در هرس کردن میوه، ۱۰ عدد در هر گل شاخه حفظ شود و در شرایط گلخانه آبیاری در حد متوسط (ETc٪۷۵) باشد.





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