

## Effect of Deficit Irrigation and Rootstocks on Fruit Weight During Post-Harvest Controlled Storage of Watermelon

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**ABSTRACT:** Grafted seedlings are used not only for protection from soil-borne diseases but also to increase tolerance to abiotic stress conditions, improve fruit quality and increase nutrient uptake in the soil. In this study, it was aimed to determine the effect of different watermelon rootstocks on weight loss of watermelon fruits, which were obtained at deficit irrigation levels and they were stored under controlled conditions for different periods. For this purpose, 2 citron watermelons, 1 open bottle gourd and 1 hybrid TZ-148 which is widely used for watermelon in Turkey were used as rootstock. The "Crimson Tide" commercial cultivar was grafted onto these rootstocks and non-grafted applications were used as control lots. 5 different irrigation levels were applied according to the plant pan coefficient such as  $kcp1 = 1.00$  ( $I_{100}$ ),  $kcp2 = 0.75$  ( $I_{75}$ ),  $kcp3 = 0.50$  ( $I_{50}$ ),  $kcp4 = 0.33$  ( $I_{33}$ ) and  $kcp5 = 0.00$  ( $I_0$ ) non-irrigated. According to the results, all watermelon rootstocks caused by less fruit weight loss compared to non-grafted applications and it has been demonstrated that using grafted rootstocks is an advantage in watermelons to be stored. On the other hand, TZ-148 commercial rootstock and citron melon 1 rootstock determined as the best rootstock in post-harvest storage. The  $I_{100}$  and  $I_{75}$  irrigation levels have approximately the same weight loss.

**Keywords:** Citron melon, deficit irrigation, watermelon storage, bottle gourd, TZ-148

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## INTRODUCTION

Watermelon is an essential vegetable of summer with its high amount of water. In addition to consuming watermelon as a fruit, it is also used in the juice industry, and its peels in pickles and jams. Consumption of 100 g of watermelon provides 30 kcal energy and contains approximately 92% water, 7.55% carbohydrate; 6.2% of them are sugar and 0.4% are fibers. It does not contain fat and cholesterol, so it is considered to be low-calorie fruits (Leskovar et al., 2004; Bruton et al., 2009). Besides, watermelon is a rich source of  $\beta$ -carotene and acts as an antioxidant and vitamin A precursor (Naz et al., 2014). On the other hand, besides being rich in minerals such as potassium and magnesium, it is also rich in B vitamins, especially B1 and B6 (Huh et al., 2008). Lycopene, which is found in rare vegetables such as watermelon, is a powerful oxygen radical scavenger and a high-effective antioxidant (Gerster, 1997).

Lycopene has been explained to have important effects against many types of cancer, especially the prostate (Giovannucci, 2002; Naz et al., 2014). On the other hand, citrulline and arginine amino acids (Perkins-Veazie et al., 2007), which are abundant in watermelon, are known to have important effects in cell anemia, immune function, wound healing and cardiovascular diseases (Tong and Barbul, 2004). Watermelon is an economically grown vegetable with a production of 118 413 465 tons in an area of 3 477 285 ha in the world. At present, China is the first producer with 79.5 million tonnes, and Turkey and Iran are the second countries with 4 million tons of production. Turkey is a highly potential country per unit area with an average of 42 tons/ha yield (FAO, 2017).

The most important problems that restrict watermelon growing are soil-borne pathogens. The most effective and sustainable method to counteract these pathogens is to determine the resistant rootstocks and to grafted fertile varieties onto these rootstocks (Yetişir and Sarı, 2003). Oda (2004) reported that cucumber (*Cucumis sativus* L.), pumpkin (*Cucurbita* spp.), watermelon (*Citrullus lanatus* Matsum et Nakai), gourd (*Lagenaria siceraria* Standl.), melon (*Cucumis melo* L.) and white gourd (*Benincasa hispida* Cogn.) used as a rootstock for watermelon cultivation. The use of grafted seedlings is used not only for protection from soil-borne diseases but also for tolerance to abiotic stress conditions, improving fruit quality and increasing nutrient uptake in the soil. Today, drought stress is the most troubling issue in watermelon growing areas. Drought is one of the most important abiotic stress factors that limit agriculture. In arid and semi-arid regions, approximately 70% of the clean water sources in people's use are managed in agriculture (Wisser et al., 2008). On the other hand, as a result of global climate change and the increasing human population, water scarcity is observed in agriculture and many other areas (Bacon, 2004; Pachauri et al., 2015). Therefore, it has become imperative to use water economically in agriculture (Yavuz et al., 2015).

Otherwise, preservation of fruits and vegetables after the harvest and extending the consumption periods is an important issue. To reduce these losses, it is imperative to determine the storage conditions. It is also known that the storage period in fruit and vegetables affects the general characteristics and growing conditions of the species and cultivars. In recent years, determining the shelf life of grafted watermelons and revealing the effects of rootstock-scion compatibility on preservation have been studied (Aras et al., 2015; Ozdemir et al., 2018). The effect of limited irrigation on the storage of watermelon was not mentioned sufficiently.

In the present study; "Crimson Tide" cultivar which was grafted onto 2 *Citrullus lanatus* var. *citroides* (citron melon at S3 level), 1 standard variety *Lagenaria siceraria* (bottle gourd) and 1 *Cucurbita maxima* x *Cucurbita moschata* (TZ-148) hybrid commercial rootstock was grown at deficit

irrigation levels. The effects of irrigation and rootstock applications on weight loss of watermelon fruits were examined during post-harvest controlled storage.

## MATERIALS AND METHODS

The study was carried out at the research area and the controlled storage room of the Selçuk University Faculty of Agriculture Horticulture Department. 2 citron watermelon (*Citrullus lanatus* var. *citroides*), 1 open-pollinated bottle gourd (*Lagenaria siceraria*), and TZ-148 hybrid cultivar (*Cucurbita maxima* x *Cucurbita moschata* hybrid) which is widely used rootstock in Turkey were examined as rootstock. Citron watermelon rootstocks were selected from our gene pool at the S3 stage. "Crimson Tide" commercial varieties were grafted on these four different rootstocks. In the research, 5 different grafting applications (4 different rootstocks and 1 non-grafted control group) and 5 different irrigation levels kcp1 = 1.00 (I<sub>100</sub>), kcp2 = 0.75 (I<sub>75</sub>), kcp3 = 0.50 (I<sub>50</sub>), kcp4 = 0.33 (I<sub>33</sub>) and kcp5 = 0.00 (I<sub>0</sub>) non-irrigated according to the plant pan coefficient were studied. The research was established according to the factorial experimental design and was established at three replicates and 20 plants for each replicate. Seedlings were planted in the experimental area in May 2018 and harvest started in August 2018. Three fruit harvested from each parcel are reserved for storage experiments. Care has been taken to avoid injury and any disease-pest effects on the fruits to be stored. After, a total of 225 fruits were weighed and numbered, and they were stored in  $+ 5 \pm 0.5$  ° C and  $70 \pm 5\%$  humidity. During storage, they were weighed 3 times, on the 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> days. With the results obtained, we tried to reveal the weight losses of the fruit in the 1 month.

The final weights of fruits were subtracted from the first weights and weight losses (%) were determined. Values are subjected to the JMP statistics program and important differences between applications are interpreted.

## RESULTS AND DISCUSSION

### Average fruit weight (g)

As a result of the study, it was observed that different rootstock and irrigation levels had statistically significant effects on the average fruit weight (LSD<sub>0,05</sub>) (Table 1). The heaviest fruits were obtained from TZ-148 (6239 g) and gourd (5964 g) rootstocks and statistically separated from other applications. On the other hand, the heaviest fruits were obtained from I<sub>100</sub> (6791 gr) and I<sub>75</sub> (6930 gr) irrigation levels and they were included in the same group statistically. When the rootstock x irrigation level interaction is examined, the I<sub>100</sub> and I<sub>75</sub> levels of all rootstocks are in the same group, while the fruit weights of 50% irrigation levels of the gourd and TZ-148 rootstocks are also included in the best group. Özmen et al. (2015) reported that different rootstocks and irrigation levels had no effect on fruit weight, and fruit weight was between 3.98-5.84 kg. Different gourd rootstocks had positive effects on fruit weight and average fruit weight was between 4018-9087 g (Yetişir and Sarı, 2018). The negative effects of deficit irrigation applications on fruit weight have also been clarified by many studies (Şensoy et al., 2007; Yavuz et al., 2015; Yoosefzadeh Najafabadi et al., 2018).

### Fruit weight loss at 10 days

It was observed that different rootstocks and irrigation levels had statistically significant effects on fruit weight losses at the end of 10-day storage (Table 2). When the fruit weight losses are examined, the most weight loss was obtained from citron watermelon 1 (1.33%) and non-grafted (1.21%) control lot. In terms of irrigation levels, the most weight loss was observed in I<sub>33</sub> (1.02%) and I<sub>0</sub> (1.45%) levels. According to the rootstock x irrigation level interaction, control x I<sub>50</sub>, citron watermelon 1 x I<sub>0</sub> and citron watermelon 2 x I<sub>0</sub> were the most weight loss applications.

**Table 1.** The effects of different irrigation levels and rootstocks on fruit weight (g)

Rootstock/wat.deficit	I <sub>100</sub>	I <sub>75</sub>	I <sub>50</sub>	I <sub>33</sub>	I <sub>0</sub>	Average
Control	6537 <sup>a-d</sup>	6391 <sup>a-d</sup>	5668 <sup>d</sup>	5517 <sup>d</sup>	2230 <sup>g</sup>	5269 <sup>C</sup>
Citron watermelon 1	6391 <sup>a-d</sup>	7046 <sup>abc</sup>	6113 <sup>bcd</sup>	5882 <sup>cd</sup>	2473 <sup>fg</sup>	5581 <sup>BC</sup>
Citron watermelon 2	6286 <sup>a-d</sup>	6426 <sup>a-d</sup>	6106 <sup>bcd</sup>	5451 <sup>d</sup>	3773 <sup>e</sup>	5608 <sup>BC</sup>
Bottle gourd	7262 <sup>ab</sup>	7232 <sup>ab</sup>	6682 <sup>a-d</sup>	5664 <sup>d</sup>	2983 <sup>efg</sup>	5964 <sup>AB</sup>
TZ-148	7482 <sup>a</sup>	7553 <sup>a</sup>	6366 <sup>a-d</sup>	6124 <sup>bcd</sup>	3673 <sup>ef</sup>	6239 <sup>A</sup>
<b>Average</b>	6791 <sup>A</sup>	6930 <sup>A</sup>	6187 <sup>B</sup>	5727 <sup>B</sup>	3026 <sup>C</sup>	
LSD <sub>0.05</sub>	Rootstock: 568		Water deficit: 568		Rootstock/water deficit: 1272	

**Table 2.** The effects of different irrigation levels and rootstocks on fruit weight loss at 10 days (%)

Rootstock/wat.deficit	I <sub>100</sub>	I <sub>75</sub>	I <sub>50</sub>	I <sub>33</sub>	I <sub>0</sub>	Average
Control	1.30 <sup>bcd</sup>	0.98 <sup>def</sup>	1.78 <sup>a</sup>	1.08 <sup>b-f</sup>	0.91 <sup>def</sup>	1.21 <sup>AB</sup>
Citron watermelon 1	1.18 <sup>b-f</sup>	1.42 <sup>abc</sup>	1.21 <sup>b-f</sup>	1.02 <sup>c-f</sup>	1.82 <sup>a</sup>	1.33 <sup>A</sup>
Citron watermelon 2	0.94 <sup>def</sup>	0.94 <sup>def</sup>	0.88 <sup>ef</sup>	1.10 <sup>b-f</sup>	1.75 <sup>a</sup>	1.12 <sup>BC</sup>
Bottle gourd	1.08 <sup>bf</sup>	1.14 <sup>b-f</sup>	1.2 <sup>b-e</sup>	0.98 <sup>def</sup>	0.84 <sup>f</sup>	1.06 <sup>BC</sup>
TZ-148	0.84 <sup>f</sup>	0.84 <sup>f</sup>	0.85 <sup>ef</sup>	1.02 <sup>c-f</sup>	1.45 <sup>ab</sup>	1.00 <sup>C</sup>
<b>Average</b>	1.06 <sup>B</sup>	1.06 <sup>B</sup>	1.04 <sup>B</sup>	1.19 <sup>AB</sup>	1.35 <sup>A</sup>	
LSD <sub>0.05</sub>	Rootstock: 0.18		Water deficit: 0.18		Rootstock/water deficit: 0.40	

### Fruit weight loss at 20 days

The effects of different rootstock and irrigation levels on fruit weight losses at the end of 20<sup>th</sup> day storage are presented in Table 3. At the end of 20 days the minimum fruit weight loss occurred at TZ-148 rootstock with 1.45%. At irrigation levels the minimum fruit weight loss was obtained from the I<sub>100</sub> irrigation level with 1.52%. When the interaction of the applications is examined the minimum weight loss was obtained from all irrigation levels except for the I<sub>0</sub> application of TZ-148 rootstock.

**Table 3.** The effects of different irrigation levels and rootstocks on fruit weight loss at 20 days (%)

Rootstock/wat.deficit	I <sub>100</sub>	I <sub>75</sub>	I <sub>50</sub>	I <sub>33</sub>	I <sub>0</sub>	Average
Control	1.69 <sup>bcd</sup>	1.99 <sup>abc</sup>	2.43 <sup>a</sup>	1.74 <sup>bcd</sup>	2.19 <sup>ab</sup>	2.01 <sup>A</sup>
Citron watermelon 1	1.72 <sup>bcd</sup>	1.60 <sup>bcd</sup>	1.98 <sup>abc</sup>	1.68 <sup>bcd</sup>	1.91 <sup>a-d</sup>	1.78 <sup>AB</sup>
Citron watermelon 2	1.42 <sup>cd</sup>	1.43 <sup>cd</sup>	1.33 <sup>d</sup>	1.61 <sup>bcd</sup>	1.80 <sup>a-d</sup>	1.52 <sup>BC</sup>
Bottle gourd	1.37 <sup>cd</sup>	1.62 <sup>bcd</sup>	1.48 <sup>cd</sup>	1.52 <sup>cd</sup>	1.61 <sup>bcd</sup>	1.52 <sup>BC</sup>
TZ-148	1.40 <sup>cd</sup>	1.34 <sup>d</sup>	1.31 <sup>d</sup>	1.49 <sup>cd</sup>	1.72 <sup>bcd</sup>	1.45 <sup>C</sup>
<b>Average</b>	1.52 <sup>B</sup>	1.59 <sup>AB</sup>	1.71 <sup>AB</sup>	1.61 <sup>AB</sup>	1.85 <sup>A</sup>	
LSD <sub>0.05</sub>	Rootstock: 0.28		Water deficit: 0.28		Rootstock/water deficit: 0.64	

### Fruit weight loss at 30 days

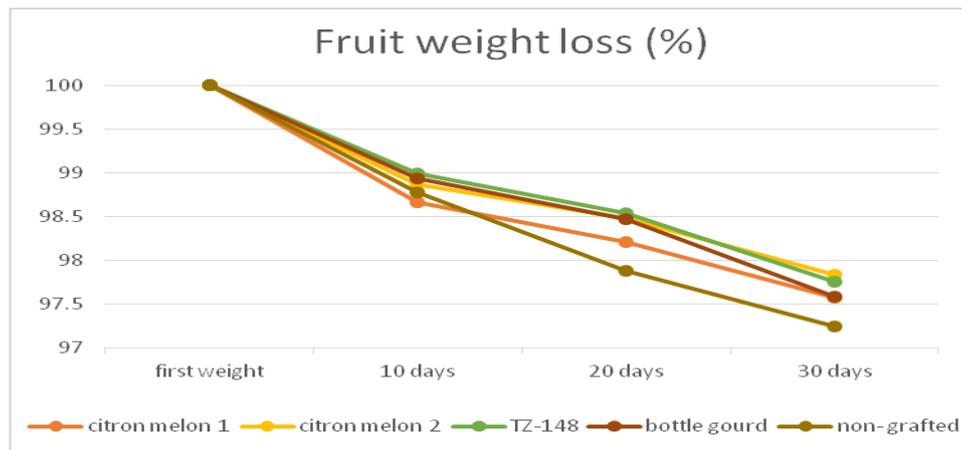
It was observed that different rootstock and irrigation levels had statistically significant effects on the final weights (30<sup>th</sup> day) of the watermelon fruits (Table 4). At the end of the 30<sup>th</sup> storage all rootstocks caused by less fruit weight loss compared to the non-grafted applications. I<sub>100</sub> (2.22%) and I<sub>75</sub> (2.23%) irrigation levels were determined as the least fruit loss levels.

Özdemir et al. (2018) reported that weight loss increased day by day in watermelon, but rootstocks had no effect on weight loss. Likewise, Aras et al. (2015) reported that rootstocks have no effect on fruit weight loss in the storage of crimson tide watermelon cultivars grafted onto different rootstocks under greenhouse conditions. Contrary to these findings, in our study, rootstocks have an important role in fruit weight loss in watermelon. It is possible to explain these different results by using different rootstocks and lower temperatures in the storage conditions.

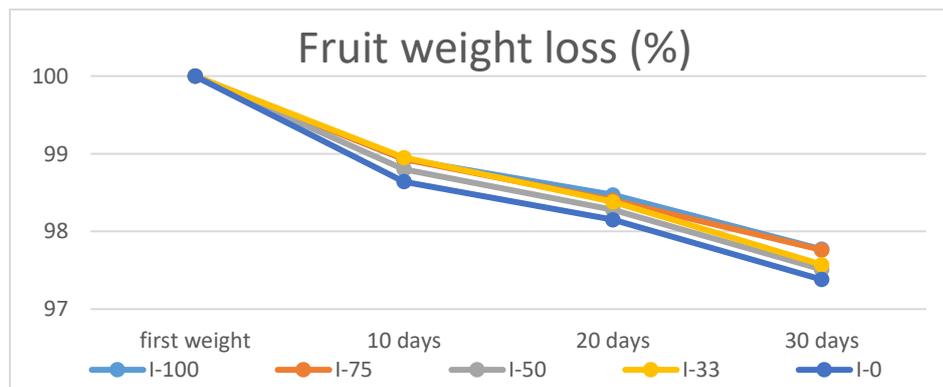
**Table 4.** The effects of different irrigation levels and rootstocks on fruit weight loss at 30 days (%)

Rootstock/wat.deficit	I <sub>100</sub>	I <sub>75</sub>	I <sub>50</sub>	I <sub>33</sub>	I <sub>0</sub>	Average
Control	2.44 <sup>e-h</sup>	2.98 <sup>a-d</sup>	2.80 <sup>a-e</sup>	2.35 <sup>c-h</sup>	3.19 <sup>ab</sup>	2.75 <sup>A</sup>
Citron watermelon 1	2.16 <sup>e-h</sup>	2.12 <sup>e-h</sup>	2.40 <sup>c-h</sup>	2.13 <sup>e-h</sup>	3.27 <sup>a</sup>	2.42 <sup>B</sup>
Citron watermelon 2	2.28 <sup>d-h</sup>	1.83 <sup>gh</sup>	1.98 <sup>fgh</sup>	2.47 <sup>b-g</sup>	2.25 <sup>d-h</sup>	2.16 <sup>B</sup>
Bottle gourd	2.07 <sup>e-h</sup>	2.26 <sup>d-h</sup>	3.09 <sup>abc</sup>	2.91 <sup>a-d</sup>	1.69 <sup>h</sup>	2.40 <sup>B</sup>
TZ-148	2.14 <sup>e-h</sup>	1.95 <sup>fgh</sup>	2.16 <sup>e-h</sup>	2.25 <sup>d-h</sup>	2.65 <sup>a-f</sup>	2.23 <sup>B</sup>
<b>Average</b>	2.22 <sup>B</sup>	2.23 <sup>B</sup>	2.42 <sup>AB</sup>	2.42 <sup>AB</sup>	2.61 <sup>A</sup>	
LSD <sub>0.05</sub>	Rootstock: 0.33		Water deficit: 0.33		Rootstock/water deficit: 0.74	

The effects of different irrigation levels and different watermelon rootstocks on the weight losses that occur in the fruit in 10-day intervals are evaluated with the figures (Figures 1 and 2). As seen in Figure 1, the effect of different watermelon rootstocks on fruit weight losses according to the non-grafted application, and all applications caused weight loss in the following days. The most weight loss occurred in non-grafted applications and all rootstocks had a positive effect on weight loss. TZ-148 and citron watermelon 2 were the least weight loss rootstocks. On the other hand, gourd and citron watermelon 1 showed approximately the same weight loss at the end of the 30<sup>th</sup> day.

**Figure 1.** The effect of different rootstocks on weight loss during the storage period in watermelon.

When Figure 2 is examined, it is seen that as the storage time increases, more weight loss occurs in applications with a high irrigation level. The most weight loss was determined in I<sub>0</sub> application. Considering the weight losses at the end of the 30<sup>th</sup> day, the I<sub>100</sub> and I<sub>75</sub> were the least fruit weight-loss applications and showed approximately the same effect. Similarly, I<sub>50</sub> and I<sub>33</sub> applications had approximately the same effect on fruit weight loss.

**Figure 2.** The effect of different irrigation levels on weight loss during the storage period in watermelon.

## CONCLUSION

The effect of different rootstocks and irrigation levels on the weight loss of watermelon fruits, which are preserved under controlled conditions has been determined. According to the results, at the end of the 30<sup>th</sup> day, all watermelon rootstocks caused by less fruit weight loss compared to non-grafted applications and it has been determined that it is an advantage to use grafted rootstocks in watermelons to be storage. Moreover, the TZ-148 commercial rootstock and citron watermelon 1 emerged as the best rootstocks for watermelon at the end of the storage period. Besides, citron watermelon 1 has been revealed to be a prominent rootstock for watermelon. As a result, as the irrigation level increases fruit weight loss increased during the storage period. As the most important result, approximately the same weight loss was observed in I<sub>100</sub> and I<sub>75</sub> irrigation levels. It is recommended in semi-arid areas, where the deficit level of I<sub>75</sub> in watermelon gives significant results.

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