DERİM

Effects of rootstocks on fruit yield and some quality traits of watermelon (*Citrullus lanatus*)

Rana KURUM[1] İbrahim ÇELİK[1] Ahmet EREN[1]

[1] Batı Akdeniz Tarımsal Araştırma Enstitüsü, Antalya

Sorumlu Yazar/Corresponding Author: rana.kurum@tarim.gov.tr

Makale Bilgisi/Article Info
Derim, 2017/34(2):91-98
doi: 10.16882/derim.2017.283012

Araştırma Makalesi/Research Article
Geliş Tarihi/Received: 02.01.2017
Kabul Tarihi/Accepted: 01.07.2017

Abstract

In this study the effects of rootstocks on watermelon fruit quality and yield were investigated by comparing grafted plants with non-grafted and self-grafted ones in open field conditions in over two consecutive years (2013-2014). The watermelon cultivar Crimson Tide was grafted onto Ferro RZ, Maximus, Nun 9075, RS 841, No:3, Strong Tosa and TZ 148 rootstocks. Non-grafted and self-grafted plants were used as control. Grafting increased the average fruit yield between 17.45% and 52.56% compared to non-grafted treatment. It was concluded that among the tested rootstocks No:3 along with Nun 9075 and TZ 148 rootstocks can be advised due to the increase in fruit yield, total soluble solids and taste panel test values and that the use of grafted plants can be advantageous alternative in watermelon production for producers.

Keywords: Fruit quality; Grafting; Rootstock; Yield; Watermelon

Anaçların karpuzun meyve verimi ve bazı kalite özellikleri üzerine etkisi

Öz

Bu çalışmada, anaçların karpuz meyve kalitesi ve verimine etkileri, aşılanmış, aşılanmamış ve kendi kökü üzerine aşılanan bitkiler ile açık alan koşullarında iki yıl karşılaştırılarak araştırılmıştır. Crimson Tide karpuz çeşidi Ferro RZ, Maximus, Nun 9075, RS 841, No:3, Strong Tosa ve TZ 148 anaçları üzerine aşılanmıştır. Aşısız ve kendine aşılı bitkiler kontrol olarak kullanılmıştır. Aşılama ortalama meyve verimini aşısız kontrole göre %17.45 ile %52.56 arasında değişen oranlarda arttırmıştır. Sonuç olarak, No:3, Nun 9075 ve TZ 148 anaçları meyve verimi, toplam suda çözünebilir kuru madde ve tat panel testi değerlerindeki artışlar nedeniyle karpuz üreticileri için tavsiye edilebilir.

Anahtar Kelimeler: Meyve kalitesi; Aşılama; Anaç; Verim; Karpuz

1. Introduction

Watermelon (*Citrullus lanatus*) originating from Africa is a popular vegetable in Turkey as well as in the world. The world watermelon production is 109 million tons and China provides 66.8% of the world production. Turkey is the second largest producer after China with 3.9 million tons in 2015 (FAO, 2016).

One of the major problems in the watermelon production is soil-borne pathogens. *Fusarium* spp., *Pythium* spp., *Phytophthora* spp., *Rhizoctonia* spp. and *Verticillium* spp. are widespread in watermelon production areas in the world and Turkey, which cause diseases such as root rot, wilting, collar blight and fruit rot (Yıldız and Delen, 1977; Sağır, 1988; Correll et al., 1991). Kırbağ and Turan (2005) reported that soils are infected with *Pythium sp., F. solani, F. oxysporium* and *R. solani* as a result of watermelon disease survey in the province of Malatya. Kurt et al. (2008) determined *F. oxysporum* f. sp. *niveum* in watermelons showing signs of wilt disease in the provinces of Adana, Mersin and Diyarbakir.

Grafting is the most popular method in watermelon production against the soil-borne pathogens and nematodes as an alternative to soil fumigants and other control methods (Crino et al., 2007). In addition to preventing soil borne diseases, the grafted plants show more tolerance to abiotic stress conditions and stimulate mineral nutrient uptake (Pulgar et al., 2000).

The first interspecific grafting of vegetables for disease management was grafting of watermelon onto a squash rootstock (*Cucurbita* *moschata* Duch.) in Japan in the 1920s (Tateishi, 1927). The cultivation of grafted vegetable plants began in Korea and Japan to prevent the reduction in yield due to disease and abiotic stress conditions in watermelon at the end of the 1920's. Grafted seedlings were commercially available for watermelon grafted onto gourd (*Lagenaria siceraria* (Mol.) Standl.) in the early 1930s in Japan. In the late 20th century grafting was introduced to Europe and Asia countries (Kubota, 2008). Currently, grafted seedlings are very widely used with more than 500 million grafted seedlings produced annually in Japan (Kobayashi, 2005), and almost 60% of vegetable production is done on these seedlings. This rate is stated to have reached up to 81 % in South Korea (Lee, 1994). Grafted seedling production in Turkey was initiated with a total of 70 000 grafted tomato seedlings for the first time in Antalya in 1998. This figure reached 120 million in 2014 and about half of them accounted for watermelon seedlings. Almost all of watermelon is produced from grafted seedlings both in open fields and under plastic tunnels in Turkey.

Watermelons are generally grafted on rootstocks of *Cucurbita maxima* x *Cucurbita moschata* hybrids, *Cucurbita moschata* and *Lagenaria siceraria* commercially. Rootstocks are effective on plant growth, yield and fruit quality (Turhan et al., 2012; Alvares-Hernandez et al., 2015), and they can thus cause variation in the fruit yield and quality associated with the combination of scion and rootstock (Alan et al., 2007). The performance of grafted plants is also affected by the environmental conditions and production methods (Cohen et al., 2007). Therefore, it is important to select watermelon compatible rootstocks and combinations of scion and rootstock showing good performance should be identified.

With respect to grafted watermelon in Turkey, studies were started by testing 10 rootstocks consisting of Lagenaria, landrace and cucurbit hybrids in 2000s (Yetişir and Sarı, 2003). Alan et al. (2007) compared watermelon variety Crisby onto TZ-148, RS-841 and Lagenaria cv. 64-18 rootstocks; Turhan et al. (2012), tested watermelon varieties Crimson Tide, Dumara and Farao onto Dynamo, RS 841 and Shintoza rootstocks; Özdemir et al. (2016) grafted watermelon varieties Crimson Tide and Crisby onto RS 841, Ferro, Argentario and Macis rootstocks and found the impact in a positive way on yield, fruit size, plant development and fruit quality of hybrid rootstocks. Balkaya (2013) reported that *C. maxima* x *C. moschata* hybrid rootstocks were quite widely used in watermelon growing areas of Turkey because of many contributions such as disease control, yield increase and fruit quality. In this context, commercial hybrid rootstocks commonly used in the watermelon production in Turkey was the main subject of this study. In the present study the effects of watermelon seedling grafting onto *C. maxima* x *C. moschata* interspecific rootstocks on fruit yield and fruit quality were investigated for open field conditions.

2. Materials and Methods

This experiment was carried out in fields located at Batı Akdeniz Agricultural Research Institute in Antalya between 2013 and 2014. A total of seven commercial hybrid rootstocks namely Ferro RZ (Rijk Zwaan), Maximus (Antalya Tarim), Nun 9075 (Nunhems), RS 841 (Monsanto), No:3 (Sakata), Strong Tosa (Syngenta) and TZ 148 (HM.Clause) were used in the experiment. All were *Cucurbita maxima* x *Cucurbita moschata* commercial hybrids.

The characteristics of the interspecific rootstocks used are as follows: Ferro RZ high resistant to *Fusarium oxysporum* and *Verticillium* sp.; Maximus resistant to Foc (*Fusarium oxysporum* f.sp. *cucumerinum*); Nun 9075 resistant to Fon 0,1 (*Fusarium oxysporum* f.sp. *niveum*) and *Verticillium dahliae*; Fom (*Fusarium oxysporum* f. sp. *melonis*); Foc; RS 841 resistant to Fusarium wilt race 1 and 2, rhizoctonia root rot and root-knot nematode; No:3 (Sakata) resistant to Fon:0,1,2 /Foc: 0,1,2 / Fom: 0,1,2,1-2; Strong Tosa resistant to Fusarium and verticillium wilt; TZ 148 resistant to Fusarium wilt race 1 and 2 and verticillium wilt; Crimson Tide (Syngenta) is a hybrid with oval type recommended for open field and protected cultivation in the spring. It is a strong hybrid variety resistant to Co 1 (*Colletotrichum orbiculare)* (Intermediate Resistance: IR) and Fon 0,1 (IR) in Turkey.

The watermelon hybrid variety Crimson Tide (CT) as a scion was used and grafted onto Ferro RZ, Maximus, Nun 9075, RS 841, No:3, Strong Tosa, TZ 148 commercial hybrid rootstocks of *C. maxima* x *C. moschata.* Non-grafted and self-grafted plants were used as a control. Grafting was made by Fidesan Seedling Company when both rootstocks and scion had their first true leaves completely developed by using the tongue-approach technique (Oda, 1999).

Grafted seedlings were planted to the field on the 12th of April in 2013 and on the 15th April in 2014. The field soil was a sandy clay loam (59.0% sand, 14.0% silt and 27.0% clay) with pH 7.6, EC 0.30 dSm^{-1} and organic matter 1.3%. Rows were 2 m apart and the distance between plants within rows was 2 m and drip irrigation system was used. The experiment was designed in a randomized complete block design (RCBD) with three replications, eight plants per replication. While 5 kg da^{-1} N, 4 kg da^{-1} P_2O_5 and 6 kg da^{-1} K_2O were applied to soil from planting to flowering, 12 kg da^{-1} N, 3.5 kg da^{-1} P_2O_5 and 17 kg da^{-1} K_2O were delivered from flowering to the end of harvest. The experiment plots were irrigated with dripping system two times a week and fertilizer applications were made through drip irrigation. Mites and aphids were controlled by chemicals according to plant protection technical instructions. During the growing season, necessary cultural practices were carried out.

Harvest time was determined based on the withering of the tendril closest to the fruit on the vine as proposed by Robinson (1997). Marketable fruits were harvested in each parcel and parcel yields were found and converted to kg da^{-1}. Fruits from plots were chosen to determine fruit rind thickness (mm), fruit flesh firmness (N), soluble solids (%), lycopene, taste panel test and fruit flesh color. Fruit firmness was measured in kg force mounting 8 mm probe on FT 327 penetrometer and converted to Newtons (N). A digital refractometer from Kruess and a digital caliper were used for determination of total soluble solids and fruit rind thickness, respectively. The nine-point Hedonic scale for evaluating fruit flesh taste was used. The taste of fruits was evaluated using a 1-9 scale by 10 panelists each replicate. 1: dislike extremely, 2: dislike very much, 3: dislike moderately, 4: dislike slightly, 5: neither like nor dislike, 6: like slightly, 7: like moderately, 8: like very much and 9: like extremely (Naes et al., 1995; Arslan, 2010). Fruit flesh color was determined by a Minolta CR-300 Chromameter. The CIE LCh color space values were used. The vertical L* axis represents lightness, ranging from 0 (black) to 100 (white). The other (horizontal) axes are represented by a* and b*. Chroma (C*) represents color saturation and was calculated using the formula $C^*=(a^{*2}+b^{*2})^{1/2}$. Hue angle ($h^0$) represents a color wheel with red-purple at an angle of 0°, yellow at 90°, bluishgreen at 180°, and blue at 270°, and it was calculated by $h^0 = \tan^{-1}(b^*/a^*)$ (McGuire, 1992).

Data for all measurements were subjected to analyses of variance and the differences between the means were compared by using LSD test (p<0.05).

3. Results and Discussion

3.1. Fruit yield

During 2013 and 2014 growing seasons, the fruit yields for watermelon grafted onto the different *C. moshata* x *C. maxima* hybrid rootstocks are given in Table 1. Fruit yields were significantly affected by the rootstocks, but there was not a significant year*rootstock interaction. All the grafted plants produced significantly higher yield than ungrafted and self-grafted ones. Grafted plants onto No:3 rootstock gave the highest fruit yield in both years with the average of 4084 kg d^{-1}. No:3 rootstock was followed by Maksimus, Nun 9075, TZ 148, Strong Tosa, RS 841, Ferro rootstocks. The lowest fruit yields with the averages of 2677 kg da^{-1} and 2695 kg da^{-1} were obtained from ungrafted and self-grafted plants, respectively.

The harvested fruit size, yield and quality are evidently affected by the scion and environmental factors, but the rootstock may also have significant effects on plant growth and fruit quality (Davis et al., 2008). Many researchers found that grafting on hybrid rootstocks promoted fruit yield increase (Yetişir et al., 2003; Alexopoulos et al., 2007; Alan et al., 2007). In this study, an increase in fruit weight was determined to be consistent with previous studies. Since the interspecific hybrid rootstocks with vigorous root system are able to absorb water and nutrient elements more efficiently in addition to disease resistance, they are superior to non-grafted plants in terms of fruit yield (Huitron-Ramirez et al., 2009).

Table 1. The values of fruit yield and quality traits for watermelon grafted onto various hybrid squash rootstocks in Antalya during 2013-2014

Rootstocks	Fruit yield (kg da^{-1})			^{0}Brix			Lycopene ($\mu g g^{-1}$)			Taste panel test (1-9 sca.)			Rind thickness (mm)			Fruit Firmness (N)		
	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.
Ferro	3573	2715	3144	9.10	11.00	10.05	60.20	66.07	63.13	6.12	7.43	6.77	16.23	13.43	14.83	10.40	9.45	9.93
Maksimus	4284	3282	3783	8.63	8.50	8.56	65.10	64.61	64.85	6.09	6.07	6.08	15.47	13.03	14.25	10.54	10.50	10.52
Nun9075	4222	3214	3718	10.28	9.75	10.01	70.12	77.91	74.02	8.13	7.43	7.78	18.50	16.29	17.39	10.85	11.00	10.92
No:3	4511	3657	4084	8.58	9.00	8.79	64.36	80.16	72.26	7.40	7.21	7.31	16.57	12.07	14.32	7.19	8.10	7.65
Strong Tosa	4235	3078	3657	9.93	8.50	9.21	77.09	84.33	80.71	6.79	6.36	6.58	18.20	15.30	16.75	8.77	8.90	8.83
RS841	3738	2750	3244	9.28	9.25	9.26	84.48	84.49	84.48	6.50	7.21	6.86	17.57	11.40	14.48	10.32	11.90	11.11
TZ148	4231	3135	3683	8.90	10.25	9.58	70.76	72.44	71.60	6.83	7.14	6.99	15.53	12.97	14.25	11.35	11.80	11.58
CT*CT	2903	2487	2695	9.20	9.50	9.35	74.42	71.05	72.74	6.98	7.07	7.03	14.27	10.83	12.55	9.67	10.55	10.11
Ungfted CT	2882	2473	2677	8.95	9.00	9.98	68.48	73.97	71.22	6.82	6.43	6.62	14.33	9.12	11.72	9.25	10.10	9.67
Average	3842	2977		9.20	9.42		70.55	75.00		6.85	6.93		16.30	12.71		9.81	10.26	
Year (Y) LSD (.05)			** 196			ns			** 1.52			ns			** 1.40		ns	
Rootstock (R) LSD (.05)			** 417			** 0.68			** 3.23			** 0.53			* 2.98		* 2.23	
Y*R LSD (.05)			ns			** 0.96			** 4.57			* 0.75			ns		ns	
CV (%)			10.4			6.17			3.77			6.50			17.44		18.91	

*: significant at p<.05 level ** : significant at p<.01 level ns: not significant Y:Year R: Rootstock Y*R:Year*Rootstock interaction

3.2. Content of soluble solids (°Brix)

The content of soluble solids was significantly affected by grafting and significance in interaction of year*rootstock was also found (Table 1). The average of total soluble solids ranged from 8.6 to 10.1% of fruit juice among rootstocks. The highest values of soluble solid content were 10.1 °Brix with Ferro RZ and 10.0 °Brix with Nun 9075, whereas the lowest values of soluble solid content were 8.8 °Brix with No:3 and 8.6 °Brix with Maximus. Ungrafted and self-grafted watermelon fruits had more soluble solid content than some grafted ones. The greatest changes in total soluble solids over years became in Strongthoza and TZ 148 along with Ferro RZ. However, Nun 9075 showed the best stability with higher soluble solids content. Turhan et al. (2012) and Tokgöz et al. (2015) showed that the content of soluble solids was affected by grafting. Alexopoulos et al. (2007) stated that grafted watermelons had less soluble solids content than the ungrafted ones. On the contrary, some researches have found no difference in the content of soluble solids between grafted and non-grafted plants (Huitron-Ramirez et al., 2009; Bruton et al., 2009; Huitron et al., 2007; Alan et al., 2007; El-Wanis et al., 2013).

3.3. Lycopene

The effects of watermelon rootstocks on lycopene contents were significant and also year*rootstock interaction was found significant (Table 1). The highest difference in lycopene content over years was in No:3 rootstocks, while the most stable rootstock was RS 841. In the present study, the average lycopene content varied between 63.1 and 84.5 µg/g. While the highest values of average lycopene contents were 84.5 µg/g and 80.7 µg/g for RS 841 and Strongthoza rootstocks, the lowest values of average lycopene contents were 63.13 µg/g and 64.9 µg/g for Ferro and Maximus rootstocks, respectively. Bruton et al. (2009) reported that lycopene content for watermelons ranged from 43.6 to 78.9 µg/g. Fekete et al. (2015) reported that interspecific hybrid rootstocks (*C. maxima* x *C. moschata*) increased the lycopene contents of watermelons. Contrary to the above-mentioned researcher, Turhan et al. (2012) didn't observe any differences in watermelon lycopene content for grafted and ungrafted plants.

3.4. Taste panel test

The effect of rootstock on the taste of watermelon fruits was found to be statistically significant and the year*rootstock interaction was also significant (Table 1). Crimson Tide CT/Maximus combination had lower taste scores than other scion/rootstock combinations. CT/Nun 9075 (7.77) and CT/No:3 (7.30) combinations had the highest taste panel test scores, whereas CT/Maximus (6.08) and CT/Strong Tosa (6.57) had the lowest taste scores. The greatest difference between years in tasting panel realized in Ferro RZ rootstock taking the lowest and highest values in two years, whereas Nun 9075 and No:3 rootstocks appeared to be higher values and more stable. On the contrary El-Wanis et al. (2013) didn't find any significant effect on the fruit taste panel test of grafted watermelons. It is known that scion/rootstock combination and environment can affect some fruit quality attributes of watermelon. Therefore, a suitable variety and rootstock combination should be carefully chosen for a particular watermelon production area.

3.5. Fruit rind thickness

Fruit rind thickness of watermelon is important in terms of resistance to transport and long shelf life. Fruit rind thickness values are presented in Table 1. These values ranged from 17.39 mm (Nun9075) to 11.73 mm (ungrafted CT). Grafting onto rootstocks affected significantly fruit rind thickness over self-grafted and ungrafted ones. The highest values were observed in watermelon fruits harvested from plants grafted onto Nun 9075 and Strong Tosa rootstocks, but the lowest values were in non-grafted watermelon fruits. Arslan (2010) found a higher rind thickness in fruits taken from grafted plants. The maximum rind thickness was measured 14.03 mm in the fruits of the watermelon variety Crisby grafted onto Ferro RZ rootstock, whereas the minimum rind thickness was measured 12.83 mm in the fruits of ungrafted Crisby. Alexopoulos et al. (2007) reported that grafting increased fruit size and yield and that the fruits of grafted plants had a thicker rind than the ungrafted. These results are in agreement with Tokgöz et al. (2015). Watermelon rind thickness varies depending on the selected rootstock. Fruit rind thicknesses of varieties grafted onto vigorous and late rootstocks increase. However, rind thickness is reduced in the fruits of varieties grafted onto weak rootstocks (Alexopoulos et al., 2007; Edelstein et al., 2014).

3.6. Fruit flesh firmness

Watermelon fruit with less fibrous and more crispy tissue is a desirable feature. Fruit flesh firmness is closely related with the fibrousness. The effect of grafting on fruit flesh firmness was found to be statistically significant (P<0.05) (Table 1). Fruit flesh firmness ranged from 11.5 to 7.6 among rootstocks. The highest values were found in TZ 148 (11.5) and RS 841 (11.1) rootstocks, while the lowest values were found in Strong Tosa (8.8) and No:3 (7.6) rootstocks. Although firmness could be affected by different factors, grafting is one of the most important factors affecting fruit flesh firmness.

Rootstocks increased firmness by 38.5% with respect to the non-grafted control (Soteriou et al., 2014). In our study, fruit flesh firmness values were found mostly higher in grafted watermelons than ungrafted ones in agreement with Huitron-Ramirez et al. (2009), Petropoulos et al. (2014) and Bruton et al. (2009). Yetişir and Sarı (2003) stated an increase of fruit flesh firmness in watermelon plants grafted onto the rootstocks of *C. maxima* x *C. moschata* interspecific hybrids. On the other hand, Huitron et al. (2007) did not find any significant effect on fruit flesh firmness of grafted watermelons.

3.7. Pulp colorimetry

Flesh color of watermelon is the important quality feature attracting consumers. Flesh color, which consists of color lightness (L* value), colour intensity (C* value) and h^0 angle, is affected by the environment and scion/rootstock combination. Flesh color lightness, the intensity of flesh color and h^0 angle are seen to have affected by rootstocks (Table 2). As shown in Table 2, the CIE LCh L* C* and h values ranged from 37.10 to 44.18, from 28.92 to 33.52 and from 28.91 to 31.40, respectively. Grafting increased fruit flesh color lightness (L*) over control excluding Nun9075 and RS841 rootstocks. All rootstocks had more intense (higher C*) color than ungrafted ones. The effect of rootstock on the hue angle (h^0) of the fruit's flesh color was found to be significant.

Table 2. The values of fruit pulp colorimetry for watermelon grafted onto various hybrid squash rootstocks in Antalya during 2013-2014

Rootstocks	L*			a*			b*			C*			h		
	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.	2013	2014	Avrg.
Ferro	44.30	42.75	43.52	23.52	29.44	26.48	13.99	16.25	15.12	27.37	33.63	30.50	30.87	28.86	29.86
Maksimus	40.53	43.73	42.13	24.64	27.60	26.12	14.09	14.70	14.40	28.39	31.27	29.83	29.78	28.04	28.91
Nun9075	41.35	40.31	40.83	25.91	29.24	27.57	15.82	15.93	15.87	30.40	33.30	31.85	31.34	28.60	29.97
No:3	40.37	43.07	41.72	24.25	27.97	26.11	14.41	15.02	14.72	28.22	31.75	29.98	30.70	28.24	29.47
Strong Tosa	42.61	42.35	42.48	20.81	28.45	24.63	13.48	16.45	14.96	24.91	33.37	29.14	32.83	29.97	31.40
RS841	36.66	37.53	37.09	25.51	30.90	28.21	15.40	17.49	16.44	31.52	35.51	33.51	29.20	29.47	29.34
TZ148	45.77	42.60	44.18	24.75	26.42	25.59	14.28	14.15	14.22	28.57	29.97	29.27	29.94	28.18	29.06
CT*CT	40.00	39.40	39.70	24.33	25.62	24.98	15.00	14.61	14.81	28.33	29.50	28.92	30.00	29.67	29.83
Ungfted CT	39.80	42.71	41.25	24.55	24.93	24.74	15.45	14.90	15.17	29.13	29.04	29.08	29.36	30.86	30.11
Average	41.26	41.60		24.25	27.84		14.66	15.50		28.54	31.92		30.45	29.10	
Year (Y)			ns			**			*			**			*
LSD $_{(.05)}$						1.24			0.82			1.24			1.05
Rootstock			*			ns			ns			*			ns
(R) LSD $_{(.05)}$			3.95									2.63			
Y*R			ns			ns			ns			ns			ns
LSD $_{(.05)}$															
CV (%)			8.10			8.60			9.76			7.40			6.38

*: significant at p<.05 level ** : significant at p<.01 level ns: not significant Y:Year R:Rootstock Y*R:Year*Rootstock interaction

The hue value (h^0) was decreased by grafting except for Strong Tosa rootstock. Fruits from Crimson Tide (CT)/CT, CT/Nun9075, CT/Ferro, CT/No:3, CT/RS841 CT/TZ148 and CT/Maximus graft combinations had lower h^0 values compared to control fruits. Our study is compatible with the results of Petropoulos et al. (2014) reporting that fruit flesh color mostly depended on the rootstock-scion combination. Fekete et al. (2015) informed us that L* value varied from 35.17 to 42.71; C* value 31.59 to 38.41; h angle 33.42 to 36.13, and that while interspecific grafting decreased h angle value, it increased C* value.

4. Conclusion

Cultivation of grafted vegetables especially grafted watermelon is a common practice in Turkey as in the world. Grafted plants are preferred due to the resistance to soil-borne pathogens and higher fruit yield and quality. The properties such as fruit yield and quality are also influenced by environment and varieties (scions). Compatible and suitable rootstock/scion combinations with high fruit yield and quality should be carefully determined in each watermelon production region. With respect to this study, it was concluded that grafting onto rootstock could increase the average fruit yield between 17,45% and 52,56% compared to non-grafted treatments and among the tested rootstocks No:3 along with Nun 9075 and TZ 148 rootstocks can be advised due to the increase in fruit yield, total soluble solids and taste panel test values.

References

Alan, Ö., Özdemir, N., & Günen, Y. (2007). Effect of grafting on watermelon plant growth, yield and quality. *Journal of Agronomy*, 6(2):362-365.

Alexopoulos, A.A., Kondylis, A., & Passam, HC. (2007). Fruit yield and quality of watermelon in relation to grafting. *Journal of Food Agriculture and Environment*, 5(1):178-179.

Arslan, Ö. (2010). Crisby karpuz çeşidinde aşılı üretimin derim sonrası kalite ve raf ömrüne etkileri. MSc Dissertation, Mustafa Kemal University, Hatay (In Turkish).

Balkaya, A. (2013). Aşılı karpuz yetiştiriciliğinde meyve kalitesini etkileyen faktörler. *Journal of TÜRKTOB*, 2(6):6-9 (In Turkish).

Bruton, B.D., Fish, W., Roberts, W., & Popham, T. (2009). The influence of rootstock selection on fruit quality attributes of watermelon. *The Open Food Science Journal*, 3(1):15-34.

Cohen, R., Burger, Y., Horev, C., Koren, A., & Edelstein, M. (2007). Introducing grafted cucurbits to modern agriculture - The Israeli experience. *Plant Disease*, 91(8):916-923.

Correll, J.C., Mitchell, J.K., & Andersen, C.R. (1991). Fruit rot of pumpkin in Arkansas caused by *Fusarium equiseti*. *Plant Disease*, 75:751.

Crino, P., Lo Bianco, C., Rouphael, Y., Colla, G., Saccardo, F., & Paratore, A. (2007). Evaluation of rootstock resistance to fusarium wilt and gummy stemblight and effect on yield and quality of a grafted 'Inodorus' melon. *HortScience*, 42(3):521-525.

Davis, A.R., Perkins-Veazie, P., Hassell, R., King, SR., & Zhang, X. (2008). Grafting effects on vegetable quality. *HortScience*, 43(6):1670-1672.

Edelstein, M., Tyutyunik, J., Fallik, E., Meir, A., Tadmor, Y., & Cohen, R. (2014). Horticultural evaluation of exotic watermelon germplasm as potential rootstocks. *Scientia Horticulturae* 165(1):196-202.

El-Wanis, Abd., El-Eslamboly, M., & Azza, S.M (2013). Impact of different grafting methods on yield and quality of watermelon. *Research Journal of Agriculture and Biological Sciences*, 9(6): 330-340.

FAO (2016). Food and Agriculture Organization of the United Nations. http://fenix.fao.org/faostat/beta/en/#data/QC. Date accessed: September 30, 2016.

Fekete, D., Mate, M.S., Bohm, V., Balazs, G., & Kappel, N. (2015). Lycopene and flesh colour differences in grafted and non-grafted watermelon. *Acta Universitatis Sapientiae Alimentaria*, 8(1):111-117.

Huitron, M.V., Diaz, M., Dianez, F., & Camacho, F. (2007). The effect of various rootstocks on triploid watermelon yield and quality. *Journal of Food Agriculture and Environment*, 5(3-4):344-348.

Huitron, R.M., Ricardez-Salinas, M., & Camacho F. (2009). Influence of grafted watermelon plant density on yield and quality in soil infested with melon necrotic spot virus. *HortScience*, 44(7):1838–1841.

Kırbağ, S., & Turan, N. (2005). Malatya'da yetiştirilen bazı sebzelerde görülen mikrofungusların tespiti, [The determination of microfungi on some vegetables cultivated in Malatya]. *Science and Engineering Journal of Firat University*, 17(3): 559-564.

Kobayashi, K. (2005). Vegetable grafting robot. *Research Journal of Food and Agriculture*, 28:15–20.

Kubota, C. (2008). Use of grafted seedlings for vegetable production in North America. *Acta Horticulturae*, 770:21-28.

Kurt, S., Dervis, S., Soylu, EM., Tok, M., Yetisir, H., & Soylu, S. (2008). Pathogenic races and inoculum density of *Fusarium oxysporum* f. sp. *niveum* in commercial watermelon fields in southern Turkey. *Phytoparasitica*, 36(2):107-116.

Lee, J.M. (1994). Cultivation of grafted vegetables. 1. Current status, grafting methods, and benefits. *HortScience*, 29(4):235–239.

McGuire, R.G. (1992). Reporting of objective colour measurement. *HortScience*, 27(12):1254-1255.

Naes, H., Holck, A.L., Axelsson, L., Andersen, H.J., & Blom, H. (1995). Accelerated ripening of dry fermented sausage by addition of a Lactobacilus proteinase. *International Journal of Food Science and Technology*, 29(6):651-659.

Oda, M. (1999). Grafting of vegetables to improve greenhouse production. Food and Fertilizer Technology Center, Extension Bulletin 480, Taipei city, Republic of China on Taiwan, 11p.

Özdemir, A.E., Çandır, E., Yetişir, H., Aras, V., Arslan, Ö., Baltaer, Ö., Üstün, D., & Ünlü, M. (2016). Effects of rootstocks on storage and shelf life of grafted watermelons. *Journal of Applied Botany and Food Quality*, 89:191-201.

Petropoulos, S.A., Olympios, C., Ropokis, A., Viachou, G., Ntatsi, G., Paraskeuopoulos, A., & Passam, H.C. (2014). Fruit volatiles, quality and yield of watermelon as affected by grafting. *Journal of Agricultural Science and Technology*, 16:873-885.

Pulgar, G., Villora, G., Moreno, D.A., & Romero, L. (2000). Improving the mineral nutrition in grafted watermelon plants: Nitrogen metabolism. *Biologia Plantarum*, 43(4):607-609.

Robinson, R.W., & Decker-Walters, D.S. (1997). Cucurbits. Wallingford, Oxon, U.K., New York, N.Y.

Sağır, A. (1988). Güneydoğu Anadolu Bölgesi’nde kavun ve karpuzlarda kök ve kökboğazı çürüklüğüne neden olan fungal etmenler, *Bitki Koruma Bülteni*, 28(3-4): 141-150 (In Turkish).

Soteriou, G.A., Kyriacou, M.C., Siomos, A.S., & Gerasopoulos, D. (2014). Evolution of watermelon fruit physicochemical and phytochemical composition during ripening as affected by grafting. *Food Chemistry*, 165:282-289.

Tateishi, K. (1927). Grafting watermelon onto pumpkin. *Journal of Japanese Horticulture* (Nihon-Engei Zasshi), 39:5-8 (in Japanese).

Tokgöz, H., Gölükcü, M., Toker, R., & Turgut, D. (2015). Karpuzun (*Citrullus lanatus*) bazı fiziksel ve kimyasal özellikleri üzerine aşılı fide kullanımı ve hasat zamanının etkileri. *Gıda*, 40(5):263-270 (In Turkish).

Turhan, A., Özmen, N., Kuşcu, H., Sebeci, M., & Şeniz, V. (2012). Influence of rootstocks on yield and fruit characteristics and quality of watermelon. *Horticultural Environment Biotechnology*, 53(4):336-341.

Yetisir, H., & Sarı, N. (2003). Effect of different rootstock on plant growth, yield and quality of watermelon. *Australian Journal of Experimental Agriculture*, 43(10):1269-1274.

Yetişir, H., Sarı, N., & Yücel, S. (2003). Rootstock resistance to Fusarium wilt and effect on watermelon fruit yield and quality. *Phytoparasitica*, 31(2):163-169.

Yıldız, M., & Delen, N. (1977). Studies on the occurrence of Fusarium wilt of cucumber in Ege Region of Turkey. *Journal of Turkish Phytopathology*, 6(3):111-117.