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FRUIT QUALITY OF 'VALENCIA' ORANGE TREES GRAFTED ON VOLKAMERIANA AND SOUR ORANGE ROOTSTOCKS GROWN IN TWO DIFFERENT REGIONS IN NORTHERN CYPRUS

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Abstract

The present study aimed to identify the effects of two citrus rootstocks (Sour orange and Volkameriana) on the fruit quality of 'Valencia' orange. Studies were carried out in Gaziveren and Lefke regions, located in Northern Cyprus. According to the results, some of the fruit quality parameters were affected by rootstock in 'Valencia' orange variety. In Lefke region, it was identified that the rootstocks play important role in terms of the fruit weight at 'Valencia' orange trees. The highest individual fruit weight and the biggest fruits at 'Valencia' orange trees were measured on Volkameriana rootstock. The highest juice amount was measured from 'Valencia' orange trees grafted on Volkameriana rootstocks (55.70%) and the lowest amount was determined in 'Valencia' orange trees grafted on Sour orange rootstock (54.10%). In Gaziveren region, rootstocks were found to affect soluble solid concentration in fruit juice. 'Valencia' orange trees grafted on Volkameriana rootstock found to be the lowest Total Soluble Solid (TSS) content. The fruit juice content of the 'Valencia' orange trees grafted on the Volkameriana and Sour orange rootstocks were measured as 57.09% and 55.55%, respectively. The results about the juice content of 'Valencia' orange trees grafted on two different rootstocks did not have statistically significant differences. Titratable acidity (TA) of the fruits was measured as 1.45% from the plants grafted on Sour orange rootstock and as 1.20% on Volkameriana rootstock. The TSS/TA of the 'Valencia' orange were also measured as 9.39 on Volkameriana rootstock and as 8.13 on Sour orange rootstock.

Key words: Citrus, Valencia orange, Rootstock, Fruit quality.

Introduction

Citrus is one of the most important fruit groups produced in the world which have different characteristics such as the longer maturation period, keeping fruits on the tree after maturity and the different qualities of the nutritional values. Citrus cultivation is mainly carried out between 40º north latitude and 40º south latitude in the world (Saunt, 2000). Although its homeland is reported to be tropical and semitropical regions, production is mainly concentrated in the subtropical climatic zones. The countries in the Mediterranean basin have suitable ecological conditions for high quality production (table production) and have an important role in citrus exportation throughout the world. Due to its location, Cyprus is among the suitable regions for high quality edible citrus cultivation. Orange is the most produced species among the Citrus species and 'Valencia' orange is mainly produced in most of the citrus orchards in Northern Cyprus. It is a late- ripening variety used in industry and fresh consumption.

It is known that the fruit size is among the most important quality parameters for consumers. When the fruit size is not at the desired level, the yield is generally not capable of covering the harvest and transportation costs. In recent years, fruit size is considered at least as important as the total yield. Increasing the fruit size sometimes results in a decrease in yield, but it is considered as more profitable in terms of the economic yield, due to the high prices of higher size fruits. This is applicable not only for small fruit and for hybrid mandarin varieties, but also for varieties such as lemon, orange and grapefruit (Guardiola & Garcia-Luis, 2000; Çelik & Islam, 2019).

Northern Cyprus has important ecological advantages for high quality citrus cultivation. High quality edible orange, mandarin, lemon and grapefruit fruits are grown in suitable regions of Northern Cyprus. In consideration with the analysis on the 2016 production area and amount, it was observed that 'Valencia' orange have the first place in the total citrus fruit production with 61.26% of the area and 65.30% of the total production. 'Valencia' orange is followed by mandarin, grapefruit, lemon, Shamouti and Washington Navel oranges respectively. It is known that the 99% of the 'Valencia' oranges are grown in Güzelyurt (Morphou) region followed by a small amount of production in Gazi Mağusa (Famagusta) and Girne (Kyrenia) regions (Anon., 2017).

The effects of rootstocks in citrus production on the crop yield and fruit quality and also ability to resistance to environmental stress conditions (i.e. salinity and viruses) are well known.

There are numerous previous studies about the effects of rootstocks on the yield and quality of citrus fruits and it is reported that there are some differences due to different environmental and soil conditions. For this reason, it is emphasized that there should be regional rootstock trials in order to propose rootstock to a region. Consequently use of rootstocks that adapted places with high pH, salinity, drought problems or cold regions, citrus orchards could be estabilished in different suitable soil and climate conditions (Al-Jaleel & Zekri, 2002; Castle, 2010).

The Sour orange rootstock is extensively used in the Northern Cyprus and it has adapted itself to the soil of this region and demonstrates a good compatibility with the other citrus species, especially with 'Valencia' orange. In addition to its properties, such as having a positive effect on fruit yield and quality, previous studies are conducted to find new rootstocks due to the susceptibility to salinized soils, nematodes and especially to virus diseases of Tristeza (CTV). Many studies were conducted on this subject in Turkey and also around the world and was found out that different rootstocks have positive effect on the fruit yield and quality, as well as various different properties of fruit itself.

In order to go further for orange cultivation in Northern Cyprus, different rootstocks need to be tested with local Sour orange rootstock in different ecological conditions and compared in terms of quality and productivity. This study aimed to identify the fruit quality properties of 'Valencia' orange grafted on Volkameriana rootstock (*Citrus volkameriana*) and on Sour orange rootstock (*Citrus aurantium*) in two different locations (Lefke and Gaziveren) Northern Cyprus. As a quality parameter, fruit size and weight, rind thickness, juice content, total soluble solids content and total acids of the grafted 'Valencia' orange fruits were tested in present study.

Materials and Methods

Experiments with 'Valencia' orange [*Citrus sinensis* (L.) Osb.] trees grafted on two different rootstocks were conducted in commercial orchards in Lefke and Gaziveren regions, located Northern Cyprus. Plant materials of present study were 'Valencia' orange [*Citrus sinensis* (L.) Osb.], Volkameriana (*Citrus volkameriana* Ten. & Pasq) rootstock and Sour orange (*Citrus aurantium* L.) rootstock.

'Valencia' orange trees of present study carried out in Gaziveren region were grafted on 1 year old Volkameriana rootstock and at the same year (2014) 'Valencia' orange trees were grafted on 5 years old Sour orange rootstock in commercial orchard. 'Valencia' orange trees grafted on the same age rootstocks in Lefke region and trees were 18 years old. In both regions of the present study 'Valencia' orange trees were grafted on Volkameriana rootstock represents the oldest trees in Northern Cyprus.

In the region of Lefke, producer was transported approximately 40 cm-high soil on the structure which is already rocky and gravelled field. The soil texture of the experimental location in Lefke was a sandy-loam with 8.1 pH and the soil texture of the experimental location in Gaziveren was a clay-loam with a pH of 7.5.

The experimental design was a randomized complete blocks design with 10 replicates and a single-tree was used for each replicate. The present investigation was carried out for 3 years from 2017 to 2019 in Lefke and for 2 years from 2018 to 2019 in Gaziveren region. Samples of 25 fruits per replicate were randomly collected at different levels and sides of the trees at harvest date for determining physical and chemical characteristics every year. Individual fruit weight, fruit length, fruit diameter, fruit index, rind thickness, number of seeds per fruit, juice content, Total Soluble Solids (TSS) content, Titratable Acidity (TA) and TSS/TA ratio were determined. Total Soluble Solid content of the fruits was measured by hand refractometer from 25 pieces of hand-squeezed fruit and Titratable Acidity was determined by the titration of 5 ml-sample from the mixed juice of 25 fruits with 0,1 N-NaOH.

Statistical analysis: Data recorded in all seasons were subjected to ANOVA using Statistical program and means were compared with Tukey test at %5 level of significance.

Results and Discussions

In present study, both leaf analysis and fruit pomological analysis findings were evaluated and the effects of rootstocks on the fruit quality were investigated.

Leaf analysis: Plant nutritional status was determined by foliar analysis performed on 80 spring-cycle leaves of the marked trees collected in each replication in September from non-fruiting shoots in 'Valencia' orange trees grafted on both rootstocks at Lefke and Gaziveren regions.

Lefke region: In Lefke region, micro and macro nutrient contents levels of 'Valencia' orange trees grafted on Volkameriana rootstock and grafted on Sour orange rootstock were examined. Leaf analysis findings and evaluations related to study in Lefke region were made according to Table 1.

Table 1. Inorganic leaf composition of 'valencia' orange trees in lefke region.

Elements	Volkameriana/ Valencia		Sour orange/ Valencia		Sufficiency levels
	Years (2016)	Years (2017)	Years (2016)	Years (2017)	
Nitrogen (%)	2.30	2.30	2.10	2.00	3-3.50
Phosphorus (%)	0.12	0.20	0.12	0.16	0.15-0.30
Potassium (%)	1.10	1.00	0.72	1.26	1-2
Sodium (%)	0.07	0.09	0.08	0.10	<0.15
Calcium (%)	5.00	5.00	6.20	7.70	3-7
Magnesium (ppm)	0.40	0.35	0.46	0.30	0.20-0.50
Iron (ppm)	47	70	53	57	60-150
Copper (ppm)	13	10	15	8	6-15
Zinc (ppm)	18	135	17	70	20-60
Manganese (ppm)	16	26	11	30	25-100

All of the trees at the study area received the same cultural practices in 2015. It was observed that nitrogen, phosphorus, iron, zinc and manganese contents of the leaves were deficient; where potassium, calcium, magnesium and copper contents of the leaves were in the optimum range while sodium content was low at 'Valencia' orange grafted on Volkameriana rootstock in 2016 (Table 1).

In Lefke region, in 2016 leaf analysis of 'Valencia' orange trees grafted on Sour orange rootstock was investigated and nitrogen, phosphorus, potassium, iron, zinc and manganese elements were found to be deficient; calcium, magnesium and copper element levels were in optimum range, while sodium element was determined low (Table1).

The soil in the study area is an alkaline. Generally plants that grown in alkaline soils iron, zinc and manganese element deficiency is an expected result. Nitrogen management has affected crop productivity and quality sometimes lower application can reduce yield and ower application can contribute unwanted ground water contaminations (Marsh, 2019). Leaf analysis helped seasonal fertilizer application. Pursuant to the completion of insufficient element levels, all trees within the trial parcel were fertilized with ammonium sulphate (2.5 kg / tree), potassium sulphate (1 kg / tree), triple super phosphate (1 kg / tree) and iron chelate (250 gr / tree). Technical zinc sulphate and technical manganese sulphate were foliar applicated.

In the study carried out in Lefke region, leaf analysis in 2017 was found out that nitrogen macro element did not reach the optimum levels for both rootstocks. Phosphorus, potassium, zinc and manganese elements reached the optimum range level at 'Valencia' orange trees on both rootstocks; iron level reached the optimum level at 'Valencia' orange trees grafted on Volkameriana rootstock after the fertilizer application (Table1).

After equal fertilizer application, leaf analysis showed that the leaves of 'Valencia' orange trees grafted on Volkameriana rootstock had a higher iron level than on Sour orange rootstock (Table 1).

Gaziveren region: In Gaziveren region, micro and macro nutrient contents levels of 'Valencia' orange trees grafted on Volkameriana rootstock and grafted on Sour orange rootstock were examined. Leaf analysis findings and evaluations related to study were made according to Table 2.

All of the trees at the study area received the same cultural practices in 2017. It was observed that the nitrogen, phosphorus, potassium, zinc and manganese elements were deficient; calcium, magnesium and copper element levels were in optimum range and sodium element level was low on both rootstocks. Iron element level was found optimum range only at Valencia' orange trees grafted on Volkameriana rootstock in 2018 year (Table 2).

In the present study soil was alkaline. Generally plants that grown in alkaline soils iron, zinc and manganese element deficiency is an expected result. After equal fertilizer application leaf analysis result showed that the leaves of 'Valencia' orange trees grafted on Volkameriana rootstock had a higher iron level than the leaves of 'Valencia' orange trees grafted on Sour orange rootstock (Table 2).

When the leaf analysis values of both Lefke and Gaziveren regions were examined, it was seen that iron levels were higher in the leaves of 'Valencia' orange trees grafted on Volkameriana rootstock than on Sour orange (Tables 1 and 2).

In a previous study conducted by Incesu et al. (2015), W. Murcot mandarin trees grafted on Volkameriana rootstock and W. Murcot mandarin trees grafted on *Swingle citrumelo* rootstock in Adana was determined that mandarins grafted on Volkameriana rootstock were higher tolerant to iron chlorosis than the mandarin grafted on *Swingle citrumelo* rootstock.

In Spain, Volkameriana was found to be more effective in iron intake than even commonly used Sour orange. Sour orange rootstock was intermediate tolerant to iron chlorosis and Volkameriana rootstock was tolerant to iron chlorosis.

Pomological analysis: In this study, the effects of different rootstocks (Volkameriana and Sour orange) on fruit quality in Lefke and Gaziveren regions were investigated.

Lefke region: In present study, the effects of Volkameriana and Sour orange rootstocks on fruit quality of 'Valencia' orange variety in Lefke region are given in Table 3 and the effects of different rootstocks on fruit quality were determined.

Table 2. Inorganic leaf composition of 'valencia' orange trees in gaziveren region.

Elements	Volkameriana/ Valencia	Sour orange/ Valencia	Sufficiency levels
Nitrogen (%)	2.20	2.60	3-3.50
Phosphorus (%)	0.11	0.11	0.15-0.30
Potassium (%)	0.74	0.84	1-2
Sodium (%)	0.11	0.11	<0.15
Calcium (%)	3.50	5.20	3-7
Magnesium (ppm)	0.38	0.31	0.20-0.50
Iron (ppm)	103	32	60-150
Copper (ppm)	6	9.10	6-15
Zinc (ppm)	10.50	12	20-60
Manganese (ppm)	15	10	25-100

Table 3. Effect of different rootstocks on the fruit quality of 'valencia' orange in lefke (Average 2017-2019).

Pomological Properties	Sour orange/ Valencia	Volkameriana/ Valencia
Fruit weight (g)	184.72 (b)	237.54 (a)
Fruit length (mm)	71.10 (b)	78.79 (a)
Fruit diameter (mm)	68.85 (b)	74.27 (a)
Fruit index	0.98 (a)	0.95 (b)
Peel thickness (mm)	3.76 (b)	4.28 (a)
Number of seeds (num)	2.74 (a)	2.23 (a)
Juice content (%)	54.10 (b)	55.70 (a)
TA (%)	1.65 (a)	1.50 (a)
TSS (%)	12.66 (a)	10.82 (b)
TSS/TA	7.81 (a)	7.42 (b)

Values followed by the same letter or letters within the same row are not statistically different according to the independent samples t-test

The fruit weight was found higher 'Valencia' orange trees grafted on Volkameriana rootstock (237.54 g) than on Sour orange rootstock (184.72 g). It was identified that the rootstocks play a significant role in the fruit weight of 'Valencia' orange in Lefke region (Table 3). Similar results were found by several previous studies. Similarly, Legua et al. (2011) reported that 'Lane Late' orange trees grafted on Volkameriana rootstock gave the heaviest fruit. In a study conducted in Saudi Arabia, the greatest individual fruit weight and the largest fruits were found from 'Olinda Valencia' orange trees grafted on *C. volkameriana* (238.65 g) and *C. macrophylla* (239.80 g), while the lightest and smallest fruits were found trees grafted on Cleopatra (188.40 g) and on Sour orange (206.93 g) (Al-Jaleel &Zekri, 2002). Tuzcu *et al*., (1999a) declared that the heaviest fruit measured 'Washington Navel' orange trees grafted on Volkameriana rootstock (277.37 g) and the lightest fruits were found on Sour orange rootstock and the fruit was measured 218.6 g. In addition, *Citrus taiwanica* (213.50 g), *Poncirus trifoliata* Raf. var. 'Beneke' (214.19 g), *Carrizo citrange* (219.31 g) and Cleopatra rootstocks (221.87 g) were obtained statistically similar results as the Sour orange rootstock.

According to the Table 3 the longest fruits were found in 'Valencia' orange trees grafted on Volkameriana rootstock (78.79 mm) and the shortest fruits were observed on Sour orange rootstock (71.10 mm). Similar results were reported with 'Washington Navel' orange trees grown on Volkameriana rootstock (81.72 mm) in Adana, Turkey by Tuzcu *et al*., (1999a).

The fruit diameter of 'Valencia' orange trees grafted on Volkameriana rootstock was measured 74.27 mm and on Sour orange rootstock was found 68.85 mm (Table 3). Tuzcu *et al*., (1999a) reported that the highest fruits diameter were found at 'Washington Navel' and 'Moro' blood orange grafted on Volkameriana rootstock (82.43 and 71.13 mm respectively). In a study conducted on three different rootstocks in Hatay, the fruit diameter of 'Valencia Late' orange was measured between 75.25-80.15 mm (Yıldız *et al*., 2013). In Saudi Arabia, Al-Jaleel and Zekri (2002) measured and found that the lowest fruit diameter was from 'Valencia' orange grafted on Sour orange rootstock as 7.15 cm and on Volkameriana rootstock as 7.45 cm. The highest values for fruit diameter was reported from 'Washington Navel' orange trees grafted on Volkameriana rootstock however the lowest diameter on the fruits grafted on Sour orange and Cleopatra mandarin rootstocks (Al Jaleel &Zekri, 2003).

The fruit index of 'Valencia' orange trees grafted on Volkameriana rootstock was measured as 0.95 and on Sour orange rootstock was found 0.98 (Table 3).

Peel thickness was the highest at fruit collected from Volkameriana rootstock as 4.28 mm and the lowest peel thickness at fruit collected from on Sour orange rootstock as 3.76 mm (Table 3). Differences in fruit peel thickness as affected in some previous studies. Al Jaleel & Zekri, (2002) noted that the peel thickness of 'Valencia' orange fruits were statistically similar on Volkameriana and on Sour orange rootstocks (4.84 mm and 4.87 mm respectively). Beside in their other study (2003) that fruit peel thickness measured as 6.08 mm at 'Washington Navel' orange trees grafted on Volkameriana rootstock and fruit peel thickness measured as 5.77 mm on Sour orange rootstock. Tuzcu *et al*., (1999a) reflected in their study conducted in Adana that the thickest fruit peel can be seen in 'Washington Navel' orange trees grafted on Volkameriana rootstock and the thinnest fruit rind can be seen in 'Moro' blood orange grafted on Sour orange rootstock (5.25 mm). Yıldız *et al*., (2013) found out the rind thickness in 'Valencia Late' orange between range of 3.98-4.85 mm.

No significant effect was noted for the rootstocks on the seed content of the fruits (Table 3).

Juice content is an important parameter for Valencia orange. The highest juice amount was determined at 'Valencia' orange trees grafted on Volkameriana rootstocks (55.70%) and the lowest amount was found in 'Valencia' orange grafted on Sour orange rootstock (54.10%). In Lefke region juice content was affected by the rootstocks. Differences in fruit juice as affected by rootstocks were also declared in some other studies. In Saudi Arabia, Al Jaleel & Zekri (2002) reported that had juice content in 'Olinda Valencia' orange trees grafted on Volkameriana rootstock as (52.77%) and on Sour orange rootstock as (51.36%). In another study conducted by Uzun *et al*., (2013) 'Valencia Late' orange trees grafted on Volkameriana rootstock found to have a juice content of 36.4%, on *Carrizo citrange* rootstock had a juice content of 43.8% and the juice content of fruits on Sour orange rootstock were measured as 43.5% in Mersin, Turkey. 'Valencia' orange trees in Florida conditions reported that fruits on different rootstocks had juice content between range of 49.2-55.3% respectively (Wutcher & Boman, 1999). In a study conducted on three different rootstocks in Hatay, Turkey the effects of rootstocks on juice content was not significantly differences and the values were between the range of 47.88-49.23% Yıldız *et al*.,(2013). 'Valencia' orange is a late-maturing variety which can be used for both edible and industrial uses (Tuzcu, 2016). The juice content is an important parameter for this species. The amount of fruit juice grafted on both rootstocks (Volkameriana and Sour orange) used in this study, was measured higher than some of the other studies.

Titratable Acidity (TA) was not affected by the rootstocks in present study. TA was measured and found statistically similar (1.65% and 1.50% respectively) (Table 3). In the study conducted in Adana, the lowest acidity was found on 'Moro' orange trees grafted on Volkameriana rootstock, *Carrizo citrange* and Cleopatra rootstock (Tuzcu *et al.*, 1999a). 'Valencia' orange trees grafted on different rootstocks found to have a titratable acidity in range of 0,68-0,92% in Florida (Wutcher & Boman, 1999). In another study conducted in Hatay, the total acids of both 'Rhode Red Valencia' and 'Valencia Late' orange trees were not affected by the rootstocks (Yıldız *et al*., 2013). As the amount of titratable acid was found to be lower in studies some many countries (Wutscher & Bowman, 1999; Auler *et al*., 2008) than the study conducted at Lefke region. When these results are examined, it has seen that acid amounts are significantly affected by ecological differences.

Total soluble solid content of the fruits were measured as 10.82% at 'Valencia' orange trees grafted on

Volkameriana rootstock and as 12.66% on Sour orange rootstocks (Table 3). The results of Wutscher & Bowman, (1999) on 'Valencia' and Auler *et al.*, (2008) on 'Valencia' oranges reported that fruits on all rootstock had total soluble solid content between a range of 9.4-11.9% and 10.3-11.4%, respectively. Tuzcu *et al.*, (1999b) found out in their study conducted in Adana that the Total soluble solid amount in 'Valencia' orange trees grafted on Sour orange rootstock was measured 11.93% and on Volkameriana rootstock was 12.64%. Furthermore, Yıldız *et al.,* (2013) determined in their study conducted in Hatay that the Total soluble solid amount in 'Valencia Late' orange trees grafted on different rootstock was range of 9.14-9.23% and found statistically similar. The differences between the studies are predicted to be caused by the effect of ecological conditions. Al Jaleel & Zekri, (2002) In the study conducted in Saudi Arabia 'Valencia' orange trees grafted on Sour orange rootstock Total soluble solid was measured as 13.48% and Total soluble solid amount on Volkameriana rootstock was 12.29%. Al Jaleel & Zekri, (2003) found that total soluble solid concentration 'Washington Navel' fruit from trees on *Carrizo citrange*, and Sour orange was the highest while it was the lowest for fruit from those on Macrophylla, Taiwanica, Rough lemon and Volkameriana. As a result same studies the amount of total soluble solid 'Washington Navel' orange grafted on Sour orange rootstock was 12.55%, Total soluble solid amount in 'Washington Navel' orange grafted on Volkameriana rootstock as 11.30%.

In the present study conducted in Lefke region TSS/TA ratio varied according to the differences particularly in the total soluble solid contents. 'Valencia' orange trees grafted on Sour orange rootstock with the highest TSS/TA ratio was measured as 7.81 and found 7.42 on Volkameriana rootstock, which has a low Total soluble solid value (Table 3). Yıldız *et al*., (2013) conducted a study in Hatay and determined the TSS/TA ratios in 'Valencia Late' orange between 6.76 and 6.80 and found statistically similar.

Gaziveren region: In present study, the effects of Volkameriana and Sour orange rootstocks on fruit quality of 'Valencia' orange variety in Gaziveren region are given in Table 4 and the effects of different rootstocks on fruit quality were determined.

Table 4. Effect of different rootstocks on the fruit quality of 'valencia' orange in gaziveren (Average 2018-2019).

Pomological Properties	Sour orange/ Valencia	Volkameriana / Valencia
Fruit weight (g)	220.91 (a)	193.98 (b)
Fruit length (mm)	76.27 (a)	72.22 (b)
Fruit diameter (mm)	73.29 (a)	71.21 (b)
Fruit index	0.96 (b)	0.99 (a)
Peel thickness (mm)	5.52 (a)	4.72 (b)
Number of seeds (num)	3.87 (a)	4.22 (a)
Juice content (%)	55.55 (a)	57.09 (a)
TA (%)	1.45 (a)	1.20 (b)
TSS (%)	11.68 (a)	11.02 (b)
TSS/TA	8.13 (b)	9.39 (a)

Values followed by the same letter or letters within the same row are not statistically different according to the independent samples t-test

In Gaziveren region the individual fruit weight was measured lower in fruits of 'Valencia' orange trees grafted on Volkameriana rootstock (193.98 g) than the fruit individual weight on Sour orange rootstock that was measured 220.91 g (Table 4). Tuzcu *et al.,* (1999b) identified in study conducted in Adana that the 'Valencia' orange fruit weight on the Sour orange rootstock was 171.14 g besides on Volkameriana rootstock fruits were measured 156.91 g. The fruit weight was found to be statistically different in that study. Uzun *et al*., (2013) found out that the highest fruits weight were 191.5 g in 'Valencia Late' orange trees grafted on Sour orange rootstock and the lowest fruit weight were measured 136.7 g on Volkameriana rootstock. Auler *et al.,* (2008) identified in their study conducted in Brazil that the lowest fruit weight in 'Valencia' orange was found on *Troyer citrange* and on Cleopatra rootstocks. Different results were obtained in the effect of rootstocks by using same materials under different ecological conditions fruit weight it is foreseen that it would be more appropriate to assess results within their own region.

In this study, the longest fruits were found in 'Valencia' orange trees grafted on Sour orange rootstock (76.27 mm) and the shortest fruits were observed on 'Valencia' orange trees grafted on Volkameriana rootstock (72.22 mm). Tuzcu *et al*., (1999b) declared that study conducted in Adana the longest fruits in 'Valencia' orange trees grafted on Sour orange rootstock were measured as 70.06 mm and on Volkameriana rootstock fruits length were measured 63.03 mm. In the study Uzun *et al.*, (2013) in Mersin, the length value of 'Valencia Late' orange trees grafted on Volkameriana rootstock was measured as 58.10 mm and on Sour orange rootstock was found as 69.90 mm.

The fruit diameter of the 'Valencia' orange grafted on Sour orange rootstock was measured as 73.29 mm while the fruit width of the 'Valencia' orange grafted on Volkameriana rootstock was 71.21 mm (Table 4). Tuzcu *et al*., (1999b) reported in their study carried out in Adana that the fruit diameter value of 'Valencia' orange trees grafted on sour orange rootstock was found 69.32 mm and on Volkameriana rootstock was measured as 68.06 mm. Uzun *et al*., (2013) found out in Mersin that the fruit diameter values of 'Valencia Late' orange trees grafted on Sour orange rootstock was 71.20 mm and on Volkameriana rootstock were measured 64.50 mm.

The fruit index of 'Valencia' orange trees grafted on Volkameriana rootstock was measured as 0.99 and on Sour orange rootstock was found 0.96 (Table 4). Tuzcu *et al*., (1999b) was found out in Adana that the fruit index in 'Valencia' orange trees grafted on Sour orange rootstock was found 0.99 and 1.01 on Volkameriana rootstock.

Peel thickness was the highest at fruit collected from Sour orange rootstock as 5.52 mm and the lowest peel thickness at fruit collected from on Volkameriana rootstock as 4.72 mm (Table 4).

Number of seeds were not significantly affected by the rootstocks. The number of seeds for 'Valencia' orange grafted on Volkameriana and Sour orange rootstocks were found to be as 4.22 and 3.87 respectively (Table 4).

The juice content on the Volkameriana rootstock was measured as 57.09% and as 55.55% on the Sour orange rootstocks. The fruit juice content was not affected by rootstocks. The juice content was found to be statistically

similar in this study (Table 4). Similarly Filho *et al*., (2007) conducted in their study in Subtropical climate in Brasil reported that Falglo and Sunburst mandarin grafted on four different rootstocks juice content were not affected by the rootstock.

In the conducted study, titratable acidity was measured as 1.45% on 'Valencia' orange trees grafted on Sour orange rootstock and 'Valencia' orange trees grafted on Volkameriana rootstock as 1.20% and a statistically significant difference was found between the values (Table 4). In the study of Uzun *et al*., (2013) conducted in Mersin, the titratable acidity in 'Valencia Late' orange trees grafted on Sour orange rootstock as 1.49% and the titratable acidity in 'Valencia Late' orange trees grafted on Volkameriana rootstock as 1.09%.

Total soluble solid content of the fruits were measured as 11.02% at 'Valencia' orange trees grafted on Volkameriana rootstock and as 11.68% on Sour orange rootstocks (Table 4). On the other hand study conducted in Mersin found out that Valencia Late' orange trees grafted on Sour orange rootstock and on Volkameriana rootstock were similar (Uzun *et al*., 2013).

TSS/TA values were measured as 8.13 on 'Valencia' orange trees grafted on Sour orange rootstocks and 9.39 on Volkameriana rootstock (Table 4). Pursuant to the study by Uzun*et al.,* (2013) conducted in Mersin the highest TSS/TA value for 'Valencia Late' orange trees was measured on Volkameriana rootstock (9.30) and the lowest value was found on Sour orange rootstock.

Conclusion

Rootstocks effects in citrus production on yield, fruit quality and also resistance to environmental conditions is well known. This study was performed in Lefke and Gaziveren in order to identify the fruit quality of 'Valencia' orange trees grafted on Sour orange and on Volkameriana rootstock. Results of present study showed that the rootstocks have significant effect on some fruit quality parameters. In Lefke region, it was identified that the rootstocks play important role on the fruit weight of 'Valencia' orange. The highest individual fruit weight and the biggest fruits were found from 'Valencia' orange trees grafted on Volkameriana rootstock (237.54 g) and the juice content was also found higher than the 'Valencia' orange grafted on Sour orange rootstock. TSS and TSS/TA were also found as lower than the fruits of 'Valencia' orange grafted on Sour orange rootstock. In Gaziveren region were analysed the effects of Volkameriana and Sour orange rootstocks determined the fruit quality at different ages. 'Valencia' orange trees grafted on Volkameriana rootstock was found low Total soluble solid content. The fruit juice amount on Volkameriana rootstock was measured as 57.09% and as 55.55% on the Sour orange rootstocks. Statistically significant difference was not found in the obtained values for juice content. In the study, titratable acidity was measured as 1.45% on 'Valencia' orange grafted on Sour orange rootstock and as 1.20% on Volkameriana rootstock. TSS/TA ratio of 'Valencia' orange was measured as 8.13 grafted on Sour orange rootstocks and 9.39 grafted on Volkameriana rootstock. These results suggest that the Volkameriana rootstock might cause early maturation for the 'Valencia' orange fruits in which that the TSS/TA ratio is higher at this graft combination. This has been an important finding for the study. Although the Sour orange is very common used rootstock for 'Valencia' orange, it is very susceptible to Tristeza (*Citrus tristeza virus)*. Findings of present study about the Volkameriana rootstock which is known to be tolerant to Tristeza should be included in further trial plantings as a potential commercial rootstock.

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