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Comparison of Yield and Pomological Characteristics of Mandarins on Three Different Rootstocks Grown in North Aegean Region of Turkey

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Abstract: Turkey is one of the most important citrus producing countries in Mediterranean Basin. Citrus production is concentrated in Mediterranean region of Turkey followed by Aegean region. Edremit, Burhaniye and Havran are north western districts with cool subtropical climate conditions along Aegean Sea. The district's economy is based on agricultural activities like olive and citrus growing. The ecological properties of the district have provided growing of high quality of mandarin fruits. In this study, fruit yield, canopy volume and pomological characteristics including fruit weight, length, diameter, rind thickness, total soluble solid content (TSS), titratable acidity (TA) and juice content (JC) were investigated in 'Owari' Satsuma (*Citrus unshiu* Marc.), 'Okitsu' Satsuma (*Citrus unshiu*) and 'Nova' mandarin (*Citrus reticulata* Blanco x (*Citrus. paradisi* Macf. x *C. reticulata* Blanco)) grafted on sour orange (*Citrus aurantium* L.), trifoliate orange (*Poncirus trifoliata* (L.) Raf.) and Carrizo citrange (*C. sinensis* cv. Washington Navel x *Poncirus trifoliata* (L.) Raf.) rootstocks. According to the obtained results, 'Okitsu' Satsuma had better yield and fruit quality performances than 'Owari' Satsuma and 'Nova' trees. Moreover, Carrizo citrange should be preferred for replacing the trifoliate orange rootstock which is used traditionally in north Aegean region of Turkey.

Keywords: *Citrus, Okitsu Satsuma, Owari Satsuma, Nova, Sour Orange, Trifoliate Orange, Carrizo citrange*

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INTRODUCTION

Citrus growing has been an ancient and traditional agricultural activity for centuries especially along the eastern Mediterranean to the west and Aegean regions in Turkey.

Total citrus production of Turkey is 4.293.007 tons in 2016. Total production is shared with 1.850.000 tons oranges, 1.337.037 tons mandarins, 850.600 tons lemons, 253.120 tons grapefruits and 2.250 tons other citrus fruits. The production and export of fresh citrus fruits of Turkey are continually in the increases. Total amount of fresh citrus export is approximately 1.600.000 tons in 2015 (TUIK, 2017).

The main citrus producing regions are located in Mediterranean and Aegean regions. North Aegean region include Burhaniye, Edremit and Havran cities located in Balıkesir province of Turkey. The region is well known for high quality table olives and olive oil. Mandarins are the second fruit crop with economic importance. North Aegean region of Turkey has importance only for mandarin production due to cool subtropical ecological conditions and frost damage risks. Satsuma mandarins and 'Nova' are the main citrus cultivars. 'Okitsu' Satsuma and 'Owari' Satsuma are the earliest ripening mandarins, with fruits being harvested late September in the North Aegean region. The early ripening, easy peeling and seedless fruits of Satsuma mandarins are well received by local markets.

'Owari' Satsuma is of ancient and unknown Japanese origin presumably from the old province of Owari in Japan. While still important in the older districts of Turkey it has largely been replaced by derivative varieties that have arisen from it through bud variation. 'Okitsu' Satsuma originated as a nucellar seedling of 'Miyagawa' Satsuma from a controlled pollination with trifoliate orange at the Horticultural Research Station, Okitsu, Japan in 1940. It is grown through mandarin producing countries including Turkey. 'Nova' mandarin, a hybrid between 'Fina' clementine and 'Orlando' tangelo at the U.S. Department of Agriculture at Orlando, Florida, USA in 1942. It is a relatively new crop in the North Aegean region of Turkey, expanding during the last 10 years, as a result of the its high fruit quality. 'Nova' fruit are medium to large for a mandarin with an attractive high internal quality (Saunt, 1990). 'Nova' is strongly self-incompatible and more fruitful if cross-pollinated.

Trifoliate orange is a traditional rootstock for all mandarin cultivars in the North Aegean region due to its strong resistance to cold damages for many decades. It is also resistant to Citrus Tristeza Virus (CTV), Phytophthora root rot (*Phytophthora citropthora* Smith and Smith) Leonian), and citrus nematode (*Tylenchulus semipenetrans* Cobb.), and trees budded on it produce high quality fruits. Many reports demonstrate a higher total soluble solid content in mandarin fruits as induced by trifoliate orange and citrange rootstocks (Zekri, 2000; Yahata et al., 2003; Canturias-Avilés et al., 2010). However, trifoliate orange is susceptible to iron chlorosis on calcareous soils. Moreover, Citrus Exocortis Viroid (CEV) is widespread in citrus production areas where trifoliate orange is used as rootstock. CEV has

resulted in great economic losses in different citrus production region of the world (Chen and Wan, 1993).

In this experiment, early performances of Carrizo citrange and sour orange rootstocks for commercial mandarin growing in the Northwestern region of Turkey were reported for replacement of trifoliate orange.

MATERIALS AND METHODS

The experimental orchard was planted in 2003 in Edremit located in the Northern Aegean region of Turkey in 6 x 4 m spacing. Trees were planted in three randomized blocks with 3 trees in each plot. The climate is cool subtropical with a mean temperature of 23.5 ºC and an annual rainfall of approximately 800 mm. The soil texture was clay-loamy and the reaction was slightly alkaline. The calcium carbonate content of the soil was generally low and there was no salinity problem. The levels of organic matter were generally low in the top soils. The trees were irrigated by drip irrigation and all nutrients were applied according to the soil and leaf analysis results. The certified buds of 'Owari' Satsuma, 'Okitsu' Satsuma and 'Nova' mandarin grafted on sour orange, trifoliate orange and Carrizo citrange rootstocks. Standard cultural practices including pest management and pruning for mandarins were applied properly.

First fruit yields were recorded from the third year after planting. Canopy volume (V) was determined from individual measurements of tree height (H) and width in parallel (D_l) and perpendicular (D_r) directions to the tree row in October 2011, assuming that the tree shape was one half prolate spheroid, by using the formula: $V = (\pi/6) \times H \times D_l \times D_r$ (Zekri, 2000).

Fruit qualities were determined in 2010 and 2011 harvesting seasons. Fruits were weighed and fruit diameter and rind thickness at the equator were measured. Juice was extracted and total soluble solids (TSS) were measured directly with a hand refraktometer. Titratable acidity (TA) were determined with 25 ml of juice by titrating with 0.31 N NaOH and expressed as citric acid equivalent. The findings reported in this experiment are the average values of 2010 and 2011 production seasons.

Data were analyzed using SAS procedures (SAS Institute, 1989). Analysis of variance was used to examine rootstock effects on yield and fruit quality characteristics. Means were separated by Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

The yields per tree, canopy volumes and fruit quality parameters were presented at Table 1., Table 2. and Table 3. The rootstocks affected the characteristics investigated in all varieties.

'Owari' Satsuma mandarin trees on sour orange had the highest yield (128.7 kg/tree) and significantly different from that on trifoliate orange (85.3 kg/tree) and Carrizo citrange (118.2 kg/tree)

(Fig.1.). The rootstocks had influenced significantly tree canopy volumes. The trees grafted on sour oranges had the biggest sizes (20.2 m^3) whereas those on the trifoliate orange the smallest (14.4 m^3). The largest and heaviest fruits were obtained from the trees on sour orange (110.0 g). Trifoliate orange induced smallest and lightest fruits (70.3 g) (Fig.2.). Fruit on sour orange had the thickest rind (4.1 mm), whereas those on trifoliate orange and Carrizo citrange the thinnest (3.3 mm). As far as the TSS content is concerned a wide variability has been noticed. Trifoliate orange and Carrizo citrange influenced significantly higher TSS value compared to sour orange. TA value was not changed among rootstocks; the differences were small and not statistically important. The TSS:TA ratio was highest for trifoliate orange and lowest for sour orange (11.65 and 9.69 respectively). Sour orange induced lower juice content than the other rootstocks. The juice content is 43.0% for the fruits produced on sour orange. The highest juice content obtained from Carrizo citrange (48.1%).

The data in Table 2 reveal that 'Okitsu' Satsuma varied for yield, canopy size and also for pomological characteristics among investigated rootstocks. The statistical analysis indicated that highly significant differences existed among rootstocks except TA content. 'Okitsu' Satsuma mandarin trees produced higher yield than 'Owari' trees. However similar rootstock effects were also observed. The yields of 'Okitsu' Satsuma were higher 21.62% for the trees on sour orange, 7.68% for trifoliate orange and 17.05% for Carrizo citrange than 'Owari' Satsuma trees on the same rootstocks. The highest yield were obtained from the trees budded on sour orange (164.2 kg/tree) whereas trifoliate orange had the lowest yield value (92.4 kg/tree) (Fig.1.). Regarding the canopy volume, a similar variability has been observed to 'Owari' trees. The trees budded on sour oranges had larger sizes than those on the trifoliate orange and Carrizo citrange. The fruits analyzed had statistically different weight values ranging from 78.1 g for trifoliate orange to 122.3 g for sour orange (Fig.2.). Similar results were obtained for fruit length and width characteristics. Sour orange obviously induced largeness either than trifoliate orange and Carrizo citrange. The values for rind thickness, the rootstocks ranged between 3.1 – 3.7 mm. Trifoliate orange and Carrizo citrange induced similar rind thickness. 'Okitsu' Satsuma fruits had higher TSS than 'Owari' Satsuma. However, similar rootstock effects were observed for TSS in 'Okitsu' fruits. The trees on trifoliate orange produced fruits with highest TSS content in the Northern Aegean ecology. Canturias-Aviles et al. (2010) reported that 'Flying Dragon' trifoliate orange had a unique effect over the 'Okitsu' trees performance, inducing lower canopy volume and higher fruit quality than Carrizo citrange.

The effects of three rootstocks on 'Nova' mandarin trees and fruits were presented in Table 3. The rootstocks affected significantly all surveyed characteristics except TA. The lowest fruit yield was obtained on trifoliate orange (74.2 kg/tree) and this result has commercial value for the growers. The trees on Carrizo citrange produced 38.41% more fruit yield than trifoliate orange, however sour orange induced the highest yield (110.6 kg/tree) (Fig.1.). No statistically important differences were observed

between Carrizo and sour orange. As far as the canopy volume is concerned, a wide variability has been noticed too similar to Satsuma trees. The trees budded on sour oranges had larger sizes than those on the trifoliate orange and Carrizo citrange. The fruits analyzed had statistically different weight values ranging from 142.7 g for trifoliate orange to 164.7 g for sour orange (Fig.2.). Fruits on Sour orange had the thickest rind (3.7 mm), whereas those on trifoliate orange and Carrizo citrange the thinnest, 3.1 mm and 3.2 mm respectively. Georgiou (2000) obtained 'Nova' fruits with thinnest rind from Troyer citrange rootstock. The highest TSS was detected in the fruits from the trees on trifoliate orange and TSS significantly higher than those on sour orange. TA contents were not affected by the rootstocks. The TSS:TA ratio was highest for trifoliate orange and lowest for sour orange. The trees budded on sour orange produced fruits with the highest juice content, whereas Carrizo citrange and trifoliate orange the lowest. These results confirm those for 'Nova' mandarin reported by Georgiou (2000).

Conclusion

Considering tree growth, yield and fruit quality, Carrizo citrange is suitable rootstock for mandarins under cool subtropical conditions of Northwestern region of Turkey. The trees on sour orange produced higher yields than on Carrizo citrange. However fruit quality were always lowest on three mandarin cultivars grafted on sour orange.

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Figures

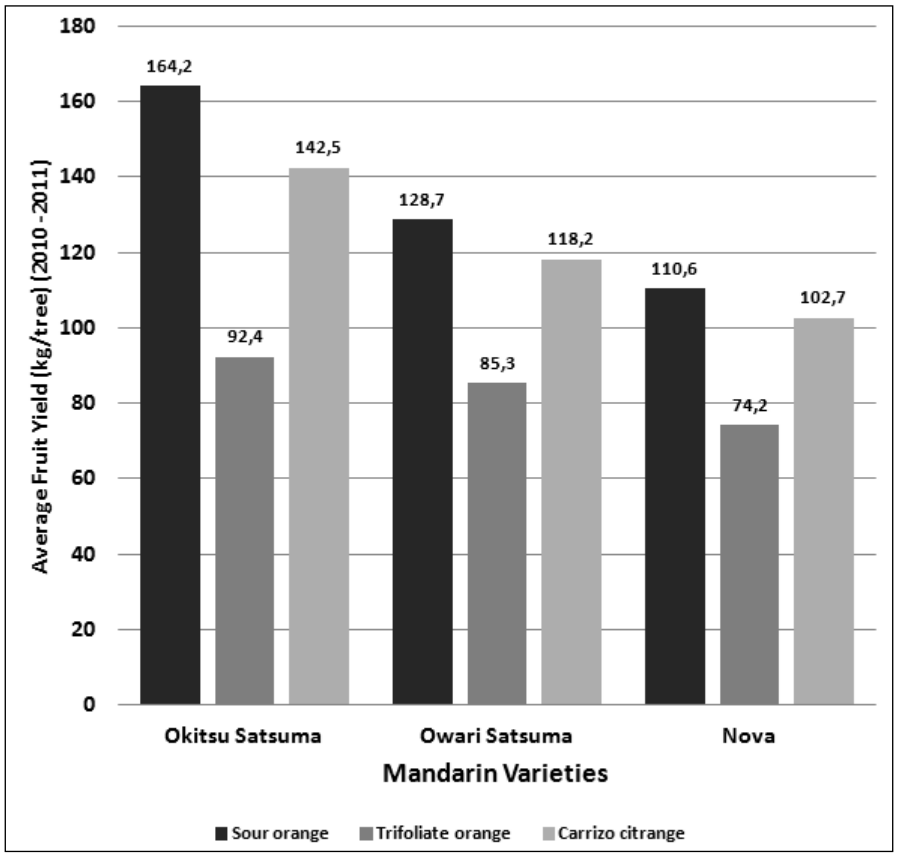

Fig.1. Comparison of the fruit yields of mandarin varieties budded on different rootstocks

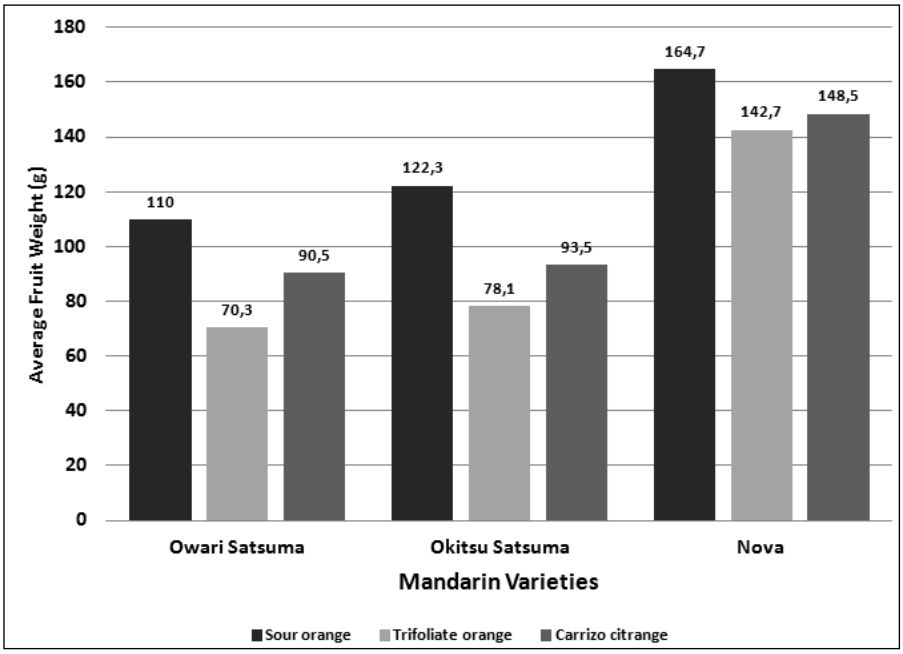

Fig.2. Comparison of the fruit weights of mandarin varieties budded on different rootstocks

Tables

Table 1. Yield, canopy volume and pomological characteristics of '*Owari'* Satsuma mandarin grafted on different rootstocks

Rootstock	Yield (kg/tree)	Canopy volume (m^3)	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Rind thickness (mm)	TSS (%)	TA (%)	TSS/TA	JC (%)
Sour orange	128.7 a	20.2 a	110.0 a	54.2 a	64.0 a	4.1 a	9.5 b	0.98	9.69 b	43.0 b
Trifoliate orange	85.3 b	14.4 b	70.3 c	41.9 c	55.5 c	3.3 b	10.6 a	0.91	11.65 a	47.9 a
Carrizo citrange	118.2 a	17.2 ab	90.5 b	46.4 b	61.4 b	3.3 b	10.1 a	0.92	10.98 a	48.1 a
Significance	**	**	**	**	**	*	*	**N.S.**	*	*

*, ** significant at 5% and 1% level respectively, N.S.: non significant

Table 2. Yield, canopy volume and pomological characteristics of '*Okitsu'* Satsuma mandarin grafted on different rootstocks

Rootstock	Yield (kg/tree)	Canopy volume (m^3)	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Rind thickness (mm)	TSS (%)	TA (%)	TSS/TA	JC (%)
Sour orange	164.2 a	24.1 a	122.3 a	51.7 a	66.1 a	3.7 a	8.5 c	0.94	9.04 b	44.1 b
Trifoliate orange	92.4 c	15.7 b	78.1 c	42.7 c	56.4 c	3.1 b	12.8 a	0.96	13.33 a	47.8 a
Carrizo citrange	142.5 b	17.2 ab	93.5 b	46.3 b	60.6 b	3.1 b	11.5 b	0.92	12.50 ab	47.4 a
Significance	**	**	**	**	**	*	*	**N.S.**	*	*

*, ** significant at 5% and 1% level respectively, N.S.: non significant

Table 3. Yield, canopy volume and pomological characteristics of '*Nova'* mandarin grafted on different rootstocks

Rootstock	Yield (kg/tree)	Canopy volume (m^3)	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Rind thickness (mm)	TSS (%)	TA (%)	TSS/TA	JC (%)
Sour orange	110.6 a	25.2 a	164.7 a	63.5 a	73.8 a	3.7 a	11.1 b	1.01	10.99 b	53.1 a
Trifoliate orange	74.2 b	17.7 b	142.7 b	57.4 b	66.7 b	3.1 b	12.4 a	0.92	13.48 a	50.5 b
Carrizo citrange	102.7 a	19.5 ab	148.5 b	59.4 b	69.1 b	3.2 b	12.1 a	0.96	12.60 a	51.2 b
Significance	**	**	**	**	**	*	*	**N.S.**	*	*

*, ** significant at 5% and 1% level respectively, N.S.: non significant