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Influence of Stock on the Early Tree Growth, Yield and Fruit Quality Traits of Apricot (*Prunus armeniaca* L.)

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ABSTRACT

This experiment was conducted in Cacak region (Western Serbia) in 2008-2010 to determine the effects of Myrobalan rootstock (*Prunus cerasifera* Ehrh.) and Blackthorn interstock (*P. spinosa* L.) on the tree growth, productivity and fruit quality traits of five apricot cultivars (*P. armeniaca* L.) grown under dry, sandy-loam and acidic soil conditions. The orchard established in 2007 at a 5.5 m × 3 m planting distance. The results showed that apricots grafted on Myrobalan appears to induce higher tree growth, yield (YI), cumulative yield (CY) and fruit weight (FW) when compared with the Blackthorn. Blackthorn showed a tendency to reduce a high vigour of apricot trees on Myrobalan, YI and fruit size. This interstock induced higher soluble solids/titratable acidity ratio (SS/TA ratio or RI) than Myrobalan. These results confirms the better adaptation of Myrobalan rootstock to dry, sandy-loam and acidic soil than Blackthorn interstock.

Keywords: Acidic soil; Apricot; Fruit quality traits; Rootstock and interstock; Productivity

Kayısının (*Prunus armeniaca* L.) Erken Ağaç Büyümesi, Verim ve Meyvenin Kalite Özelliklerine Anacının Etkisi

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ÖZET

Bu çalışma, Myrobalan anacı (*Prunus cerasifera* Ehrh) ve Blackthorn ara anacının (*P. spinosa* L.) kıraç, kumlu ve asidik topraklarda yetiştirilen beş kayısı (*P. armeniaca* L.) çeşidinde büyüme, verim ve meyve kalitesine etkilerini belirlemek amacıyla, 2008-2010 yıllarında Batı Sırbistan'ın Cacak bölgesinde yapılmıştır. Bahçe 5.5 m x 3 m dikim aralığında 2007 yılında kurulmuştur. Myrobalan üzerine doğrudan ara anacı kullanmadan aşılı kayısılarda Blackthorn ara anacı kullanmaya göre daha kuvvetli büyüme, verim, kümülatif verim ve meyve ağırlığında artışlar gözlenmiştir. Blackthorn, ara anacının kayısı ağaçlarının doğrudan Myrobalan'a aşılamaya göre verim ve meyve boyutunda azaltma eğilimi gösterdiği belirlenmiştir. Bu ara anaç, Myrobalan'dan daha yüksek bir suda çözünebilir katı madde miktarı/titre edilebilir asitlik oranı beraberinde getirmiştir. Bu sonuçlara göre Myrobalan anacının doğrudan kullanılması, Blackthorn ara anacı kullanılması durumunda ağaçların kuru, killi kumlu ve asidik topraklara daha iyi adaptasyon göstermiştir.

Anahtar sözcükler: Asidik toprak; Kayısı; Meyvenin kalite özellikleri; Anaç ve ara anaç; Verimlilik

1. Introduction

The apricot (*P. armeniaca* L.) fruit is highly appreciated by consumers and is one of the most important fruit species grown in the world. The greatest amount of the world's apricot production comes from the countries around the Mediterranean Sea, that is, Turkey (Güner & Gezer 2001) Spain, Italy, France, and Greece (Drogoudi et al 2008). Serbia has a great potential to produce many different kinds of fruits as a result of the wide variety of soil and environmental conditions. Apricot is one of them by 27 to 41 thousand tons yearly production (FAOSTAT 2011). The most important apricot-growing area in Serbia is the Region of Cacak located in Western Serbia. However, the major factors limiting the intensive spread of apricot in Serbia include: blossoms killed by spring frosts, sudden (premature) wilting - Apoplexy, winter killing of flower buds prior to bloom, *Plum pox virus* infection in apricot trees and the absence of quality rootstock (Milošević et al 2010). On the other hand, in Region of Cacak, the most limiting edaphic factors are excessively dry, shallow, sandy-loam and acidic soils with a very low pH. In these conditions, the most widely used rootstocks are Myrobalan seedlings (*P. cerasifera* Ehrh.) and/or autochthonous plum cultivars belong to *P. domestica* L. ('Belošljiva', 'Petrovača') and *P. insititia* L. ('Trnošljiva'). For example, 'Belošljiva' had good soil adaptation, good graft compatibility, but problems of excessive suckering and *Plum pox virus* infection are limiting its use (Paunovic 1977).

The controversies regarding rootstocks for the apricot speak of the very complex nature of this problem and of the need to study it with a view to establishing the most suitable rootstocks for set and/or each apricot cultivar. In general, the rootstock provides the growth characteristics of the apricot tree (Hernández et al 2010), fruit size and fruit quality (Son & Küden 2003), yield and yield efficiency (Egea et al 2004) and orchard system (Southwick & Yeager 1999; Kapel 2003). Just as important is the role of interstock (Vachun 1983). However, few refer to the agronomic performance of adequate rootstocks (Egea et al 2004; Hernández et al 2010), especially of interstock, for apricot (Southwick & Weis 1998; Djuric & Keserovic 1999). Myrobalan seedlings are the most common rootstock in Serbian apricot orchards (Paunovic 1977), since the plum rootstocks are preferred for apricots in heavy and water logged soils (Güleryüz et al 1996). Additionally, apricot grafted on Myrobalan seedlings has a number of disadvantages, such as incompatibility, unstable yield, excessive vigour, nonuniform growth, early onset and late termination of the growing season, winter killing of blossom buds, frequent occurrence of apoplexy, susceptible to *Pseudomonas* ssp., and low yield (Crossa-Raynaud & Audergon 1987). The numerous defects of Myrobalan are trying to eliminate or mitigate the use of other rotstocks and/or interstocks in some Serbian apricot orchards (Djuric & Keserovic 1999). For example, data from literature indicated that Blackthorn as rootstock reduces tree vigour, and also induced precocity, cropping efficiency, frost hardy, possible tolerance to *Pseudomonas* ssp., wide soil adaptation, better fruit size and fruit colour (Southwick & Weis 1998). Our hypothesis is that Blackthorn as interstock could exhibit the similar traits as mentioned above.

The present study was carried out over four years after planting with five apricot cultivars, grafted on Myrobalan rootstock and Blackthorn interstock, and grown on typical dry, shallow, sandy-loam and acidic soil conditions in the

Cacak region (Western Serbia). The aim of this study was to evaluate the influence of above rootstock and/or interstock on the tree growth, precocity, yield performances and fruit quality attributes of five apricot cultivars.

2. Materials and Methods

2.1. Plant material and field trial

The three Serbian ('Aleksandar', 'Biljana' and 'Vera') and two introduced ('Harcot' and 'Roxana') apricot cultivars were evaluated during 2008 to 2010. Cultivars were grafted on Myrobalan seedlings and on Blackthorn interstock. Myrobalan is a high vigour plum species, whereas Blackthorn gave a low vigour tree. The cultivars were grafted directly on Myrobalan rootstock at 60 cm above ground level. The Blackthorn interstock were grafted onto Myrobalan stock at 20 cm above ground level, and the cultivars were grafted on interstocks at 60 cm above ground level. Myrobalan rootstock and Blackthorn interstock grafted onto Myrobalan stock showed good anchorage, although they expressed different vigour. The trial was conducted at an experimental orchard located in Prislonica near Cacak, Western Serbia (43°53'N latitude; 20°21'E longitude; 340 m altitude). The trees, spaced at 5.5 m × 3 m, were planted in 2007; training system was open vase. This training system controlled tree vigour by pruning in the summer. The orchard was managed following the usual standard procedures under non-irrigated practices. The experiment was established in a randomized block design with five trees for each stock-scion and stock-interstock-scion combination in four replicates. Tree growth, YI, YE and fruit quality traits were evaluated over three consecutive years (2008-2010), i.e. from second to fourth year after planting.

2.2. Soil and weather conditions

Soil in the trial was dry, shallow and acidic, with 1.68% organic matter, 0.16% N_{TOT}, 178 mg kg^{-1} P_2O_5, 220 mg kg^{-1} K_2O, 0.39% CaO, 6.2 mg kg^{-1} MgO, and a sandy-loam texture. The soil pH in 0.01M KCl was in the range from 4.86 (0-30 cm) to 4.33 (31-60 cm soil depth). In general, soil conditions were poor for normal vegetative and reproductive growth of apricot trees, as previously reported (Son & Küden 2003).

The climate is maritime temperate or Cfb (Kottek et al 2006) with moderate to strong winters, and hot and semi to dry summers. In 2008 and 2010, the average air temperatures during calendar year were higher than normal refers, and lower in 2009 than the long-term average (Table 1). The average temperature for the growing season was much higher in 2008 and 2009, and lower in 2010 than the normal refers. Also, in all years, air temperatures in May, June and July were much higher than normal values. Total rainfall during year was much lower in 2008 and higher in 2009, especially in 2010, than the long-term period. Total rainfall for vegetative cycle was lower in 2008 and 2009, and higher in 2008 than the normal values, respectively (Table 1). The lack of rainfall before and during harvest period may have had a negative effect on the rate of some evaluated traits in the present study.

2.3. Growth measurement and yield

Trunk circumference was measured and calculated during the end of vegetative cycle 20 cm above the graft union, and the trunk cross-sectional area (TCSA) was calculated (cm^2). YI per tree, CY and yield efficiency (YE) (ratio of final yield in kg per final TCSA in cm^2) of each stock-scion and stock-interstock-scion combination were computed from the harvest data. All measurements were performed on five trees with four replicates for each stock-scion and stock-interstock-scion combination. The data are given in kg $tree^{-1}$ and kg cm^{-2}, respectively.

2.4. Fruit quality traits

FW was determined using a Tehnica ET-1111 technical scale (Iskra, Horjul, Slovenia) in 20 randomly selected fruits in four replicates for each stock-scion and stock-interstock-scion combination. The data are given as g.

Fruit quality traits such as soluble solids content (SS), total sugars content (TS), titratable acidity (TA), SS/TA ratio or RI and flesh firmness

Table 1-Monthly and growing season air temperature and rainfall for Cacak in 2008-2010 period
Çizelge 1-2008-2010 döneminde Cacak bölgesinde görülen aylık ve yetiştirme dönemindeki hava sıcaklığı ve yağış miktarı

Month	*Air temperature, °C*				*Rainfall, mm*			
	2008	2009	2010	NR[1]	2008	2009	2010	NR[1]
January	1.7	0.7	0.9	0.3	26.0	50.0	33.0	36.6
February	5.5	2.6	3.0	2.3	8.0	32.0	52.0	30.7
March	8.5	8.1	7.9	6.8	53.5	42.5	54.5	50.2
April	13.7	14.8	13.3	11.5	35.5	12.5	52.0	33.3
May	19.4	20.2	17.9	16.8	36.0	43.0	98.8	59.3
June	23.3	21.4	21.3	20.0	79.0	98.4	81.0	86.1
July	23.5	24.0	23.5	21.5	95.6	41.0	90.0	75.5
August	25.3	24.7	23.7	21.2	36.0	35.5	78.5	50.0
September	15.9	19.2	17.3	16.7	73.0	30.0	25.0	42.7
October	14.0	11.6	10.0	11.4	30.5	91.5	63.0	61.7
November	8.2	8.7	10.3	6.0	32.0	72.0	54.6	52.9
December	4.9	3.7	1.8	1.4	36.0	97.0	37.0	56.7
Mean or total for year	13.7	10.6	12.6	11.3	541.1	645.4	719.4	635.3
Mean or total for growing season	19.3	19.4	16.5	17.0	385.6	351.9	488.3	408.6

[1]NR: Normal refers to the long-term average (45-year average, i.e. 1965-2010 period)

(FF) were measured and calculated immediately after picking (commercial maturity stage). The SS (ºBrix) was determined at 20 °C with a Milwaukee MR 200 (ATC, Rocky Mount, USA) hand refractometer. The TS was determined using the Luff-Schoorl method and is expressed as percentage of fresh weight, while the TA was measured by neutralization to pH 7.0 with 0.1N NaOH, and data are given as percentage of malic acid. On the basis of the measured data, SS/TA ratio (RI) was calculated. The FF was measured on opposite paired cheeks (where the skin was removed) using a Bertuzzi Penetrometer FT-327 (Facchini, Alfonsine, Italy) equipped with an 8-mm cylindrical plunger. Data are given in kg cm^2.

2.5. Data analysis

Data obtained were statistically analyzed using two-way analysis of variance (ANOVA). The experiment had a 2 (stock) × 5 (cultivar) factorial design. The treatment means were compared using LSD test at $P \leq 0.05$, using the MSTAT-C statistical computer package (Michigan State University, East Lansing, MI, USA). The figures are performed by the Statistica program (SPSS Inc., SYSTAT version 6.0, Statistics, Chicago, IL, USA). The data are displayed as means ± standard error (±SE), and P values less than 0.05 are considered statistically significant.

3. Results and Discussion

3.1. Evaluation of tree growth, yield characteristics and fruit weight

Tree vigour, as measured by TCSA, was significantly affected by the stocks and cultivars starting from the second year after planting (Table 2). Myrobalan produced significantly higher final TCSA value than Blackthorn for 28.60%. The greatest final TCSA was observed in 'Biljana' and the lowest in 'Vera'; in the rest cultivars tree vigour was intermediate (Table 2). Additionally, on Myrobalan, the greatest TCSA was observed in 'Biljana' and lowest in 'Vera' (Figure 1a). In contrast, on Blackthorn, the lowest TCSA was registered in 'Biljana' and the highest in 'Harcot' (Figure 1b). This data show that trees of cultivars on Blackthorn grow more slowly than on Myrobalan rootstock (Crossa-Raynaud & Audergon 1987), and being a less vigour interstock with a good capacity to control vigour

Table 2-The influence of Myrobalan rootstock and Blackthorn interstock on tree vigour, cumulative yield, yield efficiency and fruit weight of five apricot cultivars, in the fourth (2010) year after planting
Çizelge 2-Dikimin ardından dördüncü yılda Myrobalan anacı ve Blackthorn ara anacının beş kayısı çeşidindeki ağaç büyümesi kümülatif verim, verim oranı ve meyve ağırlığa etkisi

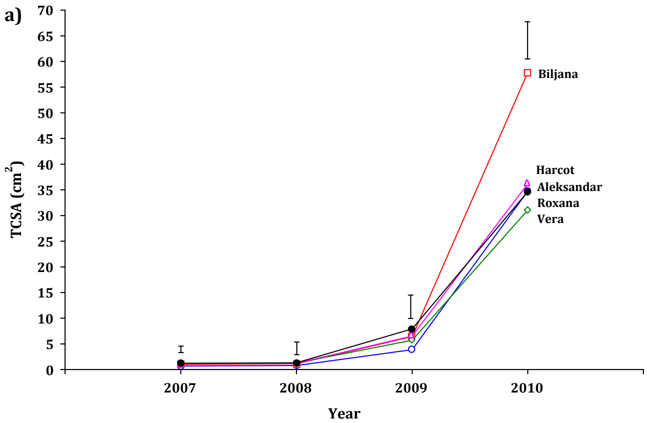
Treatment		TCSA, cm^2	Yield, kg $tree^{-1}$ Year - 2010	Cumulative yield, kg $tree^{-1}$ 2008-2010	Yield efficiency, kg cm^{-2}	Fruit weight, g
Stock (A)						
Myrobalan		38.88 ± 4.41 a	11.01 ± 2.18 a	17.44 ± 3.38 a	0.30 ± 0.07 a	81.28 ± 4.91 a
Blackthorn		27.76 ± 1.22 b	8.16 ± 1.61 b	12.76 ± 2.53 b	0.29 ± 0.05 a	53.41 ± 5.13 b
Cultivar (B)						
Aleksandar		31.38 ± 3.33 c	9.83 ± 1.46 b	15.90 ± 2.51 b	0.31 ± 0.01 ab	60.71 ± 13.31 d
Biljana		41.50 ± 9.31 a	5.88 ± 0.87 d	8.89 ± 1.33 e	0.16 ± 0.04 b	58.90 ± 12.30 e
Vera		28.28 ± 2.77 d	6.58 ± 0.98 c	10.35 ± 1.78 d	0.23 ± 0.01 ab	61.68 ± 17.78 c
Harcot		34.07 ± 2.09 b	9.06 ± 1.35 b	14.62 ± 2.21 c	0.26 ± 0.03 ab	69.89 ± 12.56 b
Roxana		31.37 ± 3.28 c	16.56 ± 2.46 a	25.71 ± 3.86 a	0.52 ± 0.02 a	85.52 ± 13.72 a
A × B						
Myrobalan	Aleksandar	34.72 ± 2.89 c	11.30 ± 1.07 c	18.41 ± 2.67 c	0.32 ± 0.02 a	74.02 ± 8.89 d
	Biljana	57.81 ± 4.33 a	6.76 ± 0.88 h	10.23 ± 1.33 h	0.12 ± 0.01 a	71.20 ± 9.13 e
	Vera	31.06 ± 1.81 f	7.56 ± 1.10 g	12.13 ± 1.98 g	0.24 ± 0.02 a	79.46 ± 8.23 c
	Harcot	36.16 ± 1.99 b	10.41 ± 1.41 d	16.84 ± 2.59 d	0.29 ± 0.03 a	82.45 ± 9.11 b
	Roxana	34.65 ± 1.34 d	19.03 ± 2.99 a	29.57 ± 3.67 a	0.55 ± 0.04 a	99.25 ± 9.98 a
Blackthorn	Aleksandar	28.05 ± 2.45 h	8.37 ± 1.65 e	13.39 ± 1.91e	0.30 ± 0.02 a	47.40 ± 6.34 g
	Biljana	25.19 ± 2.86 j	5.01 ± 0.87 j	7.56 ± 1.01 j	0.20 ± 0.01 a	46.60 ± 4.33 g
	Vera	25.51 ± 2.09 i	5.60 ± 0.89 i	8.57 ± 1.34 i	0.22 ± 0.01 a	43.90 ± 5.19 h
	Harcot	31.98 ± 2.87 e	7.71 ± 0.99 f	12.41 ± 1.72 f	0.24 ± 0.02 a	57.33 ± 7.76 f
	Roxana	28.09 ± 2.33 g	14.10 ± 1.73 b	21.85 ± 3.13 b	0.50 ± 0.04 a	71.80 ± 8.13 e
$LSD_{0.05}$						
Stock (A)		0.015	0.005	0.026	0.198	0.579
Cultivar (B)		0.024	0.008	0.041	0.313	0.915
A × B		0.033	0.035	0.058	0.443	1.295

TCSA: trunk cross-sectional area; the same small letters in columns shows insignificant differences ($P \leq 0.05$) by LSD test among cultivars.

under dry, sandy-loam and acidic soil conditions. Given the above, apricot trees grafted onto Blackthorn interstock can be planted at shorter distances apart, resulting in reduced vigour (Vachun 1983; Sadhu 1989; Southwick & Weis 1998; Djuric & Keserovic 1999). For this reason, high and semi high-density cultivation systems with Blackthorn interstocks can be valuable in apricot as it is the case in other fruit species. However, as the Cacak Region has insufficient irrigation water, seedling rootstocks should continue to be used in this area, as previously described by Paunovic (1977). Similar data reported Son & Küden (2003).

In the first bearing year (2008), YI was very low, and there were no statistically significant rootstock and interstock differences (data not shown). However, in the next bearing years, especially in 2010, differences between rootstock and interstock became evident, Myrobalan provided higher YI per tree for all cultivars than Blackthorn (Table 2). In that year, YI was also affected by the type of cultivar, being always greater in 'Roxana', and the smaller in 'Biljana'. This may be due to the fact that Afgan cultivar 'Roxana' adapted well to the soil and climatic conditions under Cacak Region, as previously found (Djuric & Keserovic 1999). The lowest YI was produced by 'Biljana'. This is probably due to their high vigour and so high TCSA (Hernández et al 2010).

Myrobalan induced significantly higher CY



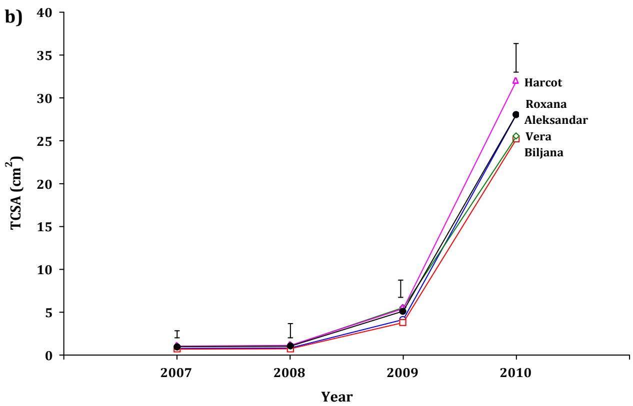


Figure 1-Myrobalan rootstock (a) and Blackthorn interstock (b) influence on trunk cross-sectional area (TCSA) of five apricot cultivars from the second (2008) to fourth (2010) year after planting. Vertical lines indicate LSD at $P \leq 0.05$

Şekil 1-Dikimin ardından ikinci ve dördüncü yıllar arasında, Myrobalan anacı (a) ve Blackthorn ara anacının (b) beş kayısı çeşidindeki gövde enine kesitine etkisi. Dikey çizgiler $P \leq 0.05$ seviyesindeki LSD yi göstermektedir

than Blackthorn, whereas no significant differences in YE between them. By the fourth year after planting, the CY for all cultivars grafted on rootstock and interstock was greater in ‘Roxana’ (Table 2). The best YE were also found in ‘Roxana’, probably due to its higher YI and cumulative production. On the other hand, the lowest CY and YE were observed in ‘Biljana’. Ondradu & Scalas (1999) and Egea et al (2004) stated that some apricot cultivars grafted on Myrobalan gave the highest yield than other rootstocks. In contrast, some authors from different countries reported that cultivars on Myrobalan produced smaller yield then on apricot seedlings and/or on other rootstock for apricot (Loreti et al 2000; Son & Küden 2003). The differences in data may be due to the results of genetic characteristic of rootstocks, interstocks, cultivars, cultural practices and climatic differences among years (Southwick & Weis 1998; Singh et al 2010).

Differences between rootstock and interstock for FW were statistically significant (Table 2). Myrobalan showed a higher mean FW than Blackthorn. The difference was 34.29% for all the evaluated cultivars. In the case of cultivars, the highest FW observed in 'Roxana' and the lowest in 'Biljana'. Kapel (2003) stated that the lower yields and smaller fruits of trees suggest that it should not be recommended as an apricot rootstock. Additionally, the early ripening cultivars 'Aleksandar', 'Biljana' and 'Vera' produced smaller fruits than late ripening 'Roksana' (Djuric & Keserovic 1999). This seems to represent a major advantage for the growers. Previous work on apricot also reported a high variability among cultivars regarding this parameter (Mehlenbacher et al 1991; Asma & Ozturk 2005; Hernández et al 2010).

Finally, significant interaction between stock and cultivar for all properties evaluated, except YE, was observed (Table 2) and indicates that apricot tree vigour, productivity and fruit size do not depend on particular parameter such as stock or cultivar, but on its combinations. In this context, Egea et al (2004) reported that interaction between apricot cultivars and rootstocks is presented as an interesting strategy for cultivar adaptation to different soil and climatic areas.

3.2. Evaluation of fruit quality traits

The values of major fruit quality traits for Myrobalan rootstock and Blackthorn interstock grafted with five apricot cultivars were presented in Table 3. Differences between rootstock and interstock for mean SS, TS, TA and FF values were little and insignificant. In the case of cultivars, the lowest SS was found in 'Roxana', and the highest value registered in 'Aleksandar'. From this point, all cultivars in both treatments showed SS values higher than 12 °Brix. Some authors reported that apricot genotypes which have a SS content >12 ºBrix, characterized by an excellent gustative quality (Egea et al 1994; Drogoudi et al 2008). Also, Ruiz & Egea (2008) stated that SS is a very important quality attribute, influencing notably the fruit taste, whereas Daza et al (2008) reported that genotype has important effect on SS content, which was confirmed our results.

The lowest TS observed in 'Roxana' and the highest in 'Biljana' and 'Vera' (Table 3). Our range values are in agreement with previous works in apricot (Audergon et al 1990; Ruiz & Egea 2008), but generally lower than those for a group of Turkish cultivars (Asma & Ozturk 2005). The differences between the present results and those of the above authors were likely due to the different eco-geographical groups of apricot genotypes studied and environmental conditions.
The TA in apricot fruit was the greatest in 'Roxana', since the lowest TA exhibited in 'Vera' and 'Aleksandar' (Table 3). Hernández et al (2010) concluded that TA in apricot fruit was not significantly affected by the rootstock, which confirmed by results in our study. Some authors stated that fruit maturity stage at the harvest date is the principal factor affecting fruit acidity and also the SS content (Ruiz & Egea 2008). In general, the range of TA values obtained in our study is in agreement with previous work in apricot (Drogoudi et al 2008; Demirtas et al 2010; Singh et al 2010).

Data in Table 3 showed that Blackthorn induced significantly higher mean SS/TA ratio or RI than Myrobalan. In the case of cultivars, the best RI was found in 'Aleksandar' and 'Vera', and the poorest in 'Roxana'. The relationship between SS and TA (RI) has an important role in consumer acceptance of some apricot, peach, nectarine and plum cultivars, as it has been previously mentioned (Crisosto et al 2004). Above authors also reported that in the case of cultivars with TA >0.90% and SS <12.0%, consumer acceptance was controlled by the interaction between TA and SS. In our study, Blackthorn induced better SS/TA ratio than Myrobalan. This result concurs with the findings of Sadhu (1989) and Southwick & Weis (1998).

The FF was not significantly affected by the rootstock and/or interstock (Table 3). Nevertheless, none of the rootstock and/or interstock induced to firmness lower than 0.5 kg cm^{-2}. Additionally, the highest FF was observed in

Table 3-The influence of Myrobalan rootstock and Blackthorn interstock on fruit quality traits of five apricot cultivars in the fourth (2010) year after planting

Çizelge 3-Dikimin ardından dördüncü yılda Myrobalan anacı ve Blackthorn ara anacının beş kayısı çeşidindeki meyvenin kalite özelliklerine etkisi

Treatment		*SS, °Brix*	*TS, %*	*TA, %*	*SS/TA ratio, RI*	*FF, kg cm^{-2}*
Stock (A)						
Myrobalan		15.84 ± 0.76 a	10.87 ± 1.22 a	0.80 ± 0.10 a	21.31 ± 3.06 b	1.78 ± 0.17 a
Blackthorn		15.83 ± 0.67 a	10.89 ± 1.25 a	0.74 ± 0.07 a	22.19 ± 2.52 a	1.81 ± 0.13 a
Cultivar (B)						
Aleksandar		17.44 ± 0.04 a	12.04 ± 0.07 b	0.62 ± 0.01 d	27.92 ± 0.59 a	1.42 ± 0.02 c
Biljana		16.07 ± 0.07 c	13.06 ± 0.04 a	0.71 ± 0.02 c	22.65 ± 0.53 c	2.07 ± 0.04 a
Vera		16.08 ± 0.08 c	12.98 ± 0.02 a	0.61 ± 0.03 d	26.43 ± 1.43 b	2.12 ± 0.09 a
Harcot		16.42 ± 0.02 b	9.75 ± 0.06 c	0.86 ± 0.07 b	19.22 ± 1.54 d	1.89 ± 0.01 b
Roxana		13.16 ± 0.19 d	6.56 ± 0.07 d	1.05 ± 0.06 a	12.53 ± 0.95 e	1.47 ± 0.13 c
A × B						
Myrobalan	Aleksandar	17.49 ± 0.99 a	11.97 ± 1.33 e	0.64 ± 0.02 def	27.33 ± 1.87 a	1.40 ± 0.02 e
	Biljana	16.15 ± 0.76 e	13.02 ± 1.67 b	0.73 ± 0.03 de	22.12 ± 1.47 c	2.04 ± 0.08 b
	Vera	16.16 ±0.37 e	13.01 ± 1.72 b	0.58 ± 0.01 f	27.86 ± 1.94 a	2.22 ± 0.09 a
	Harcot	16.44 ± 0.57 c	9.70 ± 1.03 g	0.93 ± 0.04 bc	17.68 ± 1.13 e	1.90 ± 0.11 c
	Roxana	12.97 ± 0.39 h	6.63 ± 0.98 h	1.12 ± 0.04 a	11.58 ± 1.09 g	1.34 ± 0.08 e
Blackthorn	Aleksandar	17.40 ± 0.82 b	12.11 ± 1.49 d	0.61 ± 0.02 ef	28.52 ± 2.02 a	1.44 ± 0.04 e
	Biljana	16.00 ± 0.91 f	13.10 ± 1.78 a	0.69 ± 0.03 def	23.19 ± 1.89 c	2.11 ± 0.07 ab
	Vera	16.00 ± 0.84 f	12.96 ± 1.64 c	0.64 ± 0.01 def	25.00 ± 1.96 b	2.03 ± 0.05 b
	Harcot	16.40 ± 0.68 d	9.81 ± 1.13 f	0.79 ± 0.04 cd	20.76 ± 1.82 d	1.88 ± 0.03 c
	Roxana	13.35 ± 0.49 g	6.49 ± 0.76 i	0.99 ± 0.05 b	13.48 ± 1.11 f	1.61 ± 0.07 d
$LSD_{0.05}$						
Stock (A)		0.023	0.006	0.072	0.603	0.055
Cultivar (B)		0.036	0.009	0.114	0.953	0.087
A × B		0.051	0.013	0.161	1.348	0.123

Abbreviations: SS: soluble solids content; TS: total sugar content; TA: titratable acidity; SS/TA: ratio between soluble solids content and titratable acidity; for data analysis see Table 2.

'Vera' and 'Biljana' and the lowest in 'Roxana' and 'Biljana'. Significant diferences among cultivars has been previously reported (Ruiz & Egea 2008). According to Scandella et al (1998) the quality standards for apricot at harvest maturity, suitable for consumers and the apricot industry, are a firmness value between 3.0 and 0.5 kg cm^{-2}, which was confirmed our results.

Strong interaction between stocks and cultivars sugested that the levels of SS, TS, TA, RI and FF in cultivars were not mutualy proportional across stocks (Table 3). These observations also indicated that stocks in our trial does not seem to be a good indicator of above properties in apricot fruits because fruit maturity stage on the harvest date, air temperature and rainfall before harvesting could influence these variations, as previously obtained (Ruiz & Egea 2008). For example, in 2008 and 2010 with high air temperatires and low rainfall before maturity (Table 1), SS, TS and RI values were higher than in 2009, whereas TA and FF values had adverse tendency (data not shown). Similar data has been previously reported (Audergon et al 1990; Crisosto et al 2004).

4. Conclusion

On dry, sandy-loam and acidic soil growing conditions, apricot trees grafted on Myrobalan rootstock appears to induce higher vigour, yield, cumulative yield and fruit weight whereas Blachthorn interstock showed higher value of ripening index. Yield efficiency, soluble solids, total sugars, titratable acidity and fruit firmness were similar in both treatments. In the case of cultivars, the more yield, cumulative yield, yield efficiency and fruit size was found in ‘Roxana’, whereas some major fruit quality traits was observed in ‘Aleksandar’ and ‘Vera’. In general, only by long-term testing of above stocks on specific soils with desired cultivars can best choices be made.

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