Performance of *Prunus* rootstocks for apricot in Mediterranean conditions

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Abstract

The influence of five rootstocks (Evrice, Krymsk® 86, Torinel, PAC 00-08 and PADAC 01-47) on flowering, fruit set, trunk cross-sectional area, yield efficiency and fruit quality parameters of apricot cultivars (*Prunus armeniaca* L.) grown in a Mediterranean agro-climatic environment was evaluated. The five rootstocks were grafted with ‘E-101’ and ‘E-404’ apricot cvs., and established in an experimental orchard in the Region of Murcia (South-eastern, Spain) in 2004. Rootstock had no significant influence on the number of flowers but affected fruit set. Evrice, PAC 00-08 and PADAC 01-47, induced a higher percentage of fruit set on the apricot cultivar ‘E-101’. The greatest TCSA was exhibited with Torinel, Evrice and PADAC 01-47. The yield efficiency was significantly greater on PADAC 01-47, because of its higher yield and cumulative production compared with the other rootstocks. Thus, differences in precocity among rootstocks became evident, PADAC 01-47 being the most efficient

rootstock for the first bearing years. The fruit quality traits were also significantly affected by rootstocks. In the case of ‘E-101’, the highest fruit weight was induced by Evrica, Krymsk® 86 and Torinel. In relation to fruit size, the smallest equatorial, suture and polar diameters were produced by fruit on PADAC 01-47 for both cultivars. The highest firmness was induced by PAC 00-08 for ‘E-101’, while in ‘E-404’ the highest firmness was induced by PADAC 01-47. The colour of fruit was also affected by the rootstock. The brightest coloured skin (high L* values) was found on Evrica, PADAC 01-47, Torinel and Krymsk® 86. The fruit weight was positively correlated with pulp yield and negatively correlated with TCSA. According to these results, higher fruit quality was found on PADAC 01-47 and Evrica.

Key words: fruit set, yield, TCSA, fruit quality

1. Introduction

Apricot (*Prunus armeniaca* L.) is mostly grown in Mediterranean countries, Russia, USA, Iran and Pakistan. Total world production of fresh fruit apricot is approximately 3.1 million tons (FAOSTAT, 2009). In the Mediterranean area, Turkey, Spain, France and Italy are the leading apricot producers and collectively account for 33% of the world’s production. According to FAOSTAT, 87,700 tons of apricots were produced in Spain in 2007. The most important apricot-growing area in Spain is the Region of Murcia, followed by the Valencia Community, both located in the South-eastern of Spain. These regions account for approximately 78% of the Spanish apricot production (MARM, 2009). In these areas, but especially in the Region of Murcia, the most limiting edaphic factors are excessively heavy and calcareous soils with a high pH that causes root asphyxia and iron-induced chlorosis (Moreno et al., 2008). In these

conditions, the most widely used rootstocks are apricot seedlings ('Real Fino' and 'Canino' cultivars) and plums known as 'Pollizos de Murcia' (*P. insititia*). The seedlings of apricots are still used in some areas, but the tendency is towards their substitution by clonal rootstocks due to lack of tree uniformity and other desirable traits (Moreno, 2009). The apricot seedling rootstocks have good compatibility with all cultivars, but they are very susceptible to *Phytophthora* and *Armillaria*, when grown under irrigated conditions.

The plum rootstocks: Marianna (*P. cerasifera* × *P. munsoniana*), Myrobalan (*P. cerasifera*) and Pollizo (*P. insititia*) have good soil adaptation, but some of them have poor graft compatibility (mainly Marianna and Myrobalans) with those cultivars known as exigent or difficult-to-graft non-congenial cultivars. The *P. insititia* or Pollizos de Murcia has in general good graft-compatibility, but problems of excessive suckering are limiting its use (Moreno, 2009).

Rootstocks are responsible for water and nutrient uptake, resistance to soil-borne pathogens and tolerance to environmental stresses (Layne, 1987). Additionally, the most important agricultural attributes of the trees as a biotic unit, such as vigour, productivity, blossom initiation, fruit set, flower set, fruit size and quality, may be strongly influenced by the rootstock (Bielecki et al., 2000; Cinelli and Loreti, 2004; Dichio et al., 2004; Jiménez et al., 2007; Zarrouk et al., 2005).

A good rootstock should be compatible with scion cultivars, resistant and/or tolerant to pest and diseases, and adapted to a wide range of soil types and climatic conditions (Cinelli and Loreti, 2004; Dichio et al., 2004; Layne, 1987). There are many different types of rootstocks being used for *Prunus* species on a worldwide basis (Rom, 1984). Each one has a particular set of advantages and limitations for adaptation to different geographical regions.

Many studies are available on the agronomic and fruit quality characterization of different apricot cultivars (Akin et al., 2008; Albuquerque et al., 2006; Asma and Ozturk, 2005; Asma et al., 2007; Balta et al., 2007; Drogoudi et al., 2008; Ruiz and Egea, 2008). However, few refer to the agronomic performance of rootstocks for apricots (Egea et al., 2004; Guerriero et al., 2006; Pennone and Abbate, 2006).

The present study was carried out over four years after grafting with two apricot cultivars, grafted on five different rootstocks, and grown on typical heavy and calcareous soil conditions in the South-eastern of Spain. The aim of this study was to assess the influence of these rootstocks on vegetative growth, yield and fruit quality of apricot cultivars.

Fruit set parameters (flower number, flower set, fruit set), plant yield (TCSA, cumulative yield and yield efficiency), physical parameters (fruit and stone weight, flesh firmness, pulp yield, skin colour) and chemical parameters (soluble solids content and acidity) were studied.

2. Materials and methods

2.1. Plant material

Three commercial (Evrice, Krymsk® 86 and Torinel) and two experimental (PAC 00-08 and PADAC 01-47) *Prunus* rootstocks were compared in a trial during a three year production period: 2006-2008 (Table 1). Rootstocks under evaluation included a plum (*P. domestica*): Torinel, used as the reference rootstock, and four interspecific hybrids.

Evrice is a low vigour plum hybrid and Krymsk® 86 is a high vigour peach-plum hybrid. Both are commercial rootstocks in Russia where they are used for apricots. They have been recently introduced into Spain for field testing. In contrast, the selections

PAC 00-08 and PADAC 01-47 are new experimental plum apricot hybrids. The five rootstocks have different levels of tolerance to root asphyxia caused by waterlogging conditions. Also, they are root-knot nematode resistant (*Meloidogyne* spp.) with exception of Kuban® 86 which is susceptible (unpublished).

Rootstocks were grafted with the apricot cultivars ‘E-101’ and ‘E-404’. This choice was due to the possible interest in these two new cultivars in the region of Murcia, because of their maturity time and good fruit quality. All rootstocks showed good anchorage, uniform growth, although they expressed different vigour.

The trial was conducted at an experimental orchard located near Cieza, Murcia, Spain (Latitude 38° 17’N – 1° 27’W). Soil conditions were poor and stony in the first layer (0-10 cm) and clayish below this level (clay-loam texture). Soil was highly calcareous with 15% content of active lime and pH = 8.5. Trial was drip irrigated. Trees were trained to the central leader system and planted at a spacing of 4 m x 2.5 m. Standard cultural practices (pruning, thinning, fertilization and treatments) were performed.

The experiment was established in a randomised block design with five single-tree replications for each scion-stock combination. Guard rows were used to preclude edge effects. Vegetative and fruit quality traits were evaluated over three consecutive years (2006-2008).

2.2. Flowering and fruit set

Flower and fruit set was measured from five trees per rootstock and six branches per tree (30 branches in total per each scion-stock combination). Branches were homogeneous in all cases with a similar length (30-60 cm), located at three different heights in the tree (low- medium- high) and marked at the phenological stage A.

Flower number was counted at the phenological stages D and E (Baggiolini, 1952), flower set at the stage G and the fruit set at the stage I. Periodical controls were carried out every 2-3 days.

Flower set percentage (FSP) was calculated as the number of flower set in relation to the total of flowers in the branch. Fruit set percentage (FS) was calculated as the number of fruit set per total open flowers (Albuquerque et al., 2003). Fruit set was determined five days before harvest time.

2.3. Plant development and plant yield

The following parameters were measured and/or calculated: trunk circumference at 10 cm above the graft union, the total yield (Kg/tree) and yield efficiency (Kg cm^{-2}). The trunk circumferences were converted into trunk cross-sectional areas (TCSA, cm^2). Cumulative yield per tree and yield efficiency of each scion-stock combination were computed from the harvest data. The plant yield efficiency (Kg cm^{-2}) was expressed as the ratio of total cumulative yield in Kg per final TCSA.

2.4. Fruit quality parameters

Fruit and stone weight (g) of apricot fruits were determined with a digital balance Sartorius (model BL-600, 0.01 g accuracy) in 40 randomly selected apricot fruits for each scion/stock combination. An electronic digital slide gauge Mitutoyo (model CD-15 DC, England, 0.01 mm accuracy) was used to measure fruit diameters and pulp thickness. Flesh firmness (FF) was determined with a Bertuzzi Penetrometer (model FT-327, Facchini, Alfonsine, Italy) equipped with an 8 mm cylindrical plunger. The measurement was performed on two opposite faces in the equatorial zone (where the skin was removed). Flesh firmness was expressed in kg cm^{-2} . Fruit sphericity was

determined as diameter polar/diameter equatorial ratio. Pulp yield percentage was calculated as [(fruit weight-stone weight) / fruit weight] x 100.

Colour determinations were made in the skin of fruit on four opposite faces in the equatorial zone and the CIELAB L^* (brightness or lightness; 0= black, 100 = white), a^* ($-a^*$ = greenness, $+a^*$ = redness) and b^* ($-b^*$ = blueness, $+b^*$ = yellowness) colour variables were measured using the chromatometer CR-300 (Minolta, Ramsey, NJ). Besides, the hue angle [$H^\circ = \arctang(b^*/a^*)$] and chroma [$C^* = (a^{*2} + b^{*2})^{1/2}$] were calculated. As suggested by McGuire (1992), hue angle and chroma have been accepted as more intuitively understandable colour variables.

The biochemical analyses were determined on six juice samples (6 apricots each) for each single-tree replication from all scion/stock combinations. The juice was extracted using a blender and filtered through a cheesecloth. Soluble solids content (SSC) was measured at 20°C with an Atago N1 hand-held refractometer (Atago Co., Tokyo, Japan); and data were given as °Brix. The method for analysis of titratable acidity (TA) was based on neutralisation (NaOH 0.1 N) to pH 8.1 and values were expressed as g/L malic acid, since this is the dominant organic acid in apricot (Souty et al., 1990; Witherspoon and Jackson, 1996). The ripeness index (RI) was calculated as the ratio of SSC/TA.

2.5. Statistical analysis

Statistical analyses were performed using SPSS 16.0 for Windows. A basic descriptive statistical analysis was followed by an analysis on variance test for mean comparisons. The method used to discriminate among the means (Multiple Range Test) was the Fisher's Least Significant Difference (LSD) procedure at 95.0% confidence

level. The relationship between quality and yield parameters was examined using a bilateral Pearson correlation.

3. Results

3.1. Flowering and fruit set

The rootstock had no influence in the number of flowers per branch or on flower set in both tested cultivars, with exception of Krymsk® 86 which induced a larger number of flowers per branch in the cultivar ‘E-101’, although the percentage of flower set was lower in this cultivar (Table 2). Rootstock had a clear influence over fruit set (Table 2). Thus, the highest percentage of fruit set was recorded with the cultivar ‘E-101’ grafted on Evrica, PAC 00-08 and PADAC 01-47. In contrast, a lower percentage of fruit set was found with ‘E-404’ grafted onto PADAC 01-47, Krymsk® 86 and Torinel.

3.2. Vigour and yield characteristics

In ‘E-101’ the greatest TCSA was exhibited with Torinel, Evrica and PADAC 01-47 (Table 3), and the lowest on Krymsk® 86. In the first year of production, 2006, yields were insignificant, and there were no differences between treatments ($P \leq 0.05$). However, in the next cropping years, differences in precocity among rootstocks became evident, PADAC 01-47 being the most efficient rootstock.

The TCSA showed by Torinel and PADAC 01-47 was related to the expected vigour of the trees. In contrast, Evrica, being a dwarfing rootstock with a good capacity to control vigour, showed a high TCSA value and a much higher than normal vigour. In turn, Krymsk® 86, which is a high vigour rootstock presented a low TCSA value and a lower than expected vigour.

The highest cumulative yield was exhibited by PADAC 01-47 and Torinel. The best yield efficiency was also found on PADAC 01-47, probably due to its higher yield and cumulative production. In contrast, the lowest yield efficiency was found on Evrica, although it was not statistically different when compared with Torinel and PAC 00-08 (Table 3). In the case of Evrica this is probably due to its high TCSA.

In ‘E-404’, Evrica rootstock showed the highest TCSA. There were no significant differences among the other rootstocks (Table 3). The cumulative yield was greatest on PADAC 01-47 and the lowest on Evrica and Torinel, the latter did not differ from Krymsk® 86 and PAC 00-08. The yield efficiency was higher on PADAC 01-47, intermediate on PAC 00-08, Torinel and Evrica, and lower on Krymsk® 86.

3.3. Fruit quality parameters

The fruit quality characteristics were also significantly affected by rootstocks (Table 4).

Fruit weight and size: In the case of ‘E-101’ apricot, the highest fruit weight was induced by Evrica, Krymsk® 86 and Torinel, while ‘E-404’ had a similar fruit weight in all rootstocks, with exception of PADAC 01-47. In general, ‘E-404’ showed a higher mean fruit weight than ‘E-101’ for all the evaluated rootstocks. In relation to fruit size, the smallest equatorial, suture and polar diameters were shown on PADAC 01-47 for both cultivars. Similarly, the lowest pulp thickness was induced by PADAC 01-47 (Table 4). Probably, the high yield showed by this rootstock affected its fruit size when compared with the other low yielding rootstocks.

Fruit firmness: Fruit firmness of ‘E-101’ and ‘E-404’ was also affected by the rootstock (Table 4). For ‘E-101’, the highest firmness was induced by PAC 00-08 and the lowest by Torinel and PADAC 01-47, while in ‘E-404’ the highest firmness was

induced by PADAC 01-47. In general, ‘E-404’ exhibited fruits of a higher consistency than ‘E-101’ with all tested rootstocks.

Fruit SSC and TA: In ‘E-101’, the greatest SSC was recorded on PADAC 01-47 (12.6 ° Brix), and the lowest on Evrica, Krymsk® 86 and PAC 00-08, although all of them did not differ significantly when compared with Torinel. In the case of ‘E-404’, a similar tendency was observed for PADAC 01-47, since the greatest SSC was exhibited by Krymsk® 86 and PADAC 01-47. The TA in fruit was not significantly affected by the rootstock (Table 4).

SSC/acid ratio (ripening index): Ripening index (RI) values were quite similar for each scion/cultivar along the study, which assures a similar ripening stage of evaluated apricots. The fruits of ‘E-101’ and ‘E-404’ from the different grafted trees did not differ significantly in their SSC/TA ratio (Table 4).

Fruit colour: Significant differences were found between rootstocks in colour parameters of ‘E-101’ and ‘E-404’ fruits (Table 5). The brightest coloured skin (high L* values) was found in fruit grafted onto Evrica, PADAC 01-47 and Torinel for ‘E-101’. For ‘E-404’, the rootstocks Evrica, Krymsk® 86 and Torinel produced the brightest fruits. In ‘E-101’, Krymsk® 86, PADAC 01-47 and Torinel induced the highest red coloured skin (high a* values). In contrast, with ‘E-404’, Torinel showed the lowest red coloured skin (low a* values). Hue angle (H°*) is expressed in degrees: 0° (red), 90° (yellow), 180° (green) and 270° (blue). ‘E-404’ showed an intense orange colour grafted on all rootstocks (the H°* values of around 55°), while ‘E-101’ showed a less intense orange color grafted on all rootstocks (the H°* values of around 70°). The C* (chroma) values which changes from 0 (dull) to 60 (vivid), was higher for ‘E-101’ grafted on Evrica and PADAC 01-47, while the highest values for ‘E-404’ were observed on Evrica and Krymsk® 86.

3.4. Analysis of correlation

The interdependence of the variables was investigated by the analysis of correlation (Table 6). The fruit weight was positively correlated with pulp yield and negatively correlated with TCSA. However, correlation between fruit weight and SSC or TA was not statistically significant. A positive correlation was found between TCSA and yield and cumulative yield. However, a negative correlation was found between TCSA and pulp yield and yield efficiency. Yield efficiency was positively correlated with cumulative yield.

4. Discussion

4.1. Flowering and fruit set

Flowering values showed by ‘E-101’ and ‘E-404’ were lower than those reported by Balta et al. (2007) in Turkish apricot cultivars.

Fruit set percentage is an expression of flower quality or fertility. Fruit set is also determined by weather conditions during bloom, which affects pollination, pollen tube growth and ovule fertility (Williams, 1965). Many studies have examined the influence of climate on fruiting with different results. Egea et al. (2004) observed the influence of the rootstock on the productive and flower bud behaviour of the apricot ‘Orange Red’ under the Mediterranean conditions. Atkinson and Taylor (1994) and Atkinson and Lucas (1996), concluded that fruit set is also genotype dependent.

In this study, Evrica, PAC 00-08 and PADAC 01-47 induced the highest percentage of fruit set over ‘E-101’. Our results are similar to those published by Balta et al. (2007) with Turkish apricot cultivars and superior to the results obtained by Albuquerque et al. (2003) for the Spanish apricot cultivar ‘Guillermo’.

4.2. Vigour and yield characteristics

Evrica showed a high TCSA value and a much higher than normal vigour, while Krymsk® 86, which is a high vigour rootstock, presented a low TCSA value and a lower than expected vigour. These opposing responses in tree development may be due to a better or worse adaptation of Evrica and Krymsk® 86 to a typical warm Mediterranean environment which is different to the cooler continental type climate from where these rootstocks were obtained in Russia. In the case of Krymsk® 86, this may also be due to some form of delayed graft-incompatibility. It is also known that incompatibility problems can occur more frequently in warmer areas (Moreno et al., 2001). In addition, the apricot cultivars used in our study as well as the limiting soil conditions could have accounted for further differences in vigour.

The low yield efficiency shown by Torinel has already been reported by Pennone and Abbate (2006).

4.3. Fruit quality parameters

In this study, the rootstocks Evrica, Krymsk® 86 and Torinel induced the highest fruit weight on 'E-101'. In contrast, 'E-404' had a similar fruit weight in all rootstocks. Previous studies by several authors on apricot have also reported a high variability among cultivars regarding this parameter (Badenes et al., 1998; Egea et al., 2004; Ledbetter et al., 1996; Pérez-González, 1992).

Regarding fruit firmness, in general, 'E-404' exhibited fruits of a higher consistency than 'E-101' with all tested rootstocks. Nevertheless, none of the rootstocks induced to a firmness lower than 0.5 kg cm⁻². According to Cemagref (1981) the quality

standards for apricot at harvest maturity are a firmness value between 3.0 and 0.5 kg cm⁻².

Regarding SSC and titratable acidity (TA), the TA in fruit was not significantly affected by the rootstock. In contrast, the greatest SSC was induced by PAC 01-47 for both cultivars. It is worthy of note that the high yield shown by PADAC 01-47 when compared with other rootstocks, did not significantly affect its SSC.

The relationship between SSC and TA (SSC/TA=RI) has an important role in consumer acceptance of some apricot, peach, nectarine and plum cultivars (Ruiz and Egea, 2008). In addition, RI has been reported to have a closer relationship with fruit eating quality than TA or SSC (Crisosto et al., 2002; Harker et al., 2002). In our study, the fruits of 'E-101' and 'E-404' from the different grafted trees did not differ significantly in their SSC/TA ratio.

The TA was negatively correlated with SSC/TA ratio, while no relationship with SSC was found, as previously reported (Badenes et al., 1998; Ruiz and Egea, 2008). However, Asma and Ozturk (2005) observed a significant correlation between SSC and TA for a group of Turkish apricot cultivars.

Color has a significant impact on consumer perception of apricot quality especially regarding fruit attractiveness (Ruiz and Egea, 2008). Fruits of trees grafted on Evrica and Torinel showed a more luminous colour (higher L* parameter) for both cultivars. On the other hand, 'E-101' trees grafted on Krymsk® 86, PADAC 01-47 and Torinel showed the highest red coloured skin (higher a* parameter). The highest C* (chroma) values were exhibited in both cultivars when grafted on Evrica.

In general, the more attractive fruits were found on Evrica, PADAC 01-47 and Torinel.

4. Conclusion

The results of this study showed that, in heavy and calcareous soil growing conditions, trees grafted on PADAC 01-47 appears to induce higher yield, yield efficiency and good fruit quality. Evrica and Torinel showed a tendency to induce a higher level of vigour when compared with the other rootstocks, which seems to reduce their yield efficiency. In the case of Krymsk® 86 further evaluation of its performance is needed because it seems to lack compatibility with some apricot cultivars in our growing conditions. The more attractive fruits and major fruit quality were found on Evrica, PADAC 01-47 and Torinel.

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Table 1. Description and origin of *Prunus* rootstocks used in this study.

Rootstock	Species	Origin*
Evrica	(<i>Prunus besseyi</i> x <i>P. salicina</i>) x <i>P. cerasifera</i>	Krymsk, Russia
Krymsk® 86	<i>P. cerasifera</i> x <i>P. persica</i>	Krymsk, Russia
Torinel	<i>P. domestica</i>	INRA, France
PAC 00-08	(<i>P. salicina</i> x <i>P. cerasifera</i>) x <i>P. armeniaca</i>	AC, Spain
PADAC 01-47	(<i>P. besseyi</i> x <i>P. armeniaca</i>) x (<i>P. cerasifera</i> x <i>P. armeniaca</i>)	AC-EEAD, Spain

* Krymsk Breeding Station, Krasnodar Region, Russian Federation; Institut National de la Recherche Agronomique (INRA), Bordeaux, France; Agromillora Catalana, Barcelona, Spain (AC) and Estación Experimental de Aula Dei, CSIC, Zaragoza, Spain (EEAD).

Table 2. Number of flowers per branch, and percentages of flower and fruit set of the apricot cultivars ‘E-101’ and ‘E- 404’ grafted on five *Prunus* rootstocks (period 2006-2008).

Rootstock	Cultivar	Number flowers /branch	Percentage Flower set	Percentage Fruti set
Evrica	E-101	47.66 a	23.89 a	73.97 b
	E-404	51.47 a	17.90 a	48.03 a
KRYMSK 86®	E-101	44.52 b	20.82 a	33.18 a
	E-404	32.05 a	29.37 b	54.57 b
PAC 00-08	E-101	59.29 a	28.23 a	78.36 b
	E-404	42.78 a	27.76 a	31.21 a
PADAC 01-47	E-101	45.23 a	24.21 a	74.42 b
	E-404	48.27 a	32.54 a	59.60 a
Torinel	E-101	55.08 a	22.90 a	65.27 a
	E-404	65.38 a	26.51 a	53.86 a

Means in the same column for each rootstock with two cultivars followed by the same letter do not differ significantly according to LSD test ($P \leq 0.05$).

447 Table 3. Effect of rootstock on vigor, cumulative yield and yield efficiency of ‘E-101’ and ‘E-104’ apricot cultivars, in the fourth (2008) year
 448 after grafting.

		TCSA (cm ²)	Yield (kg tree ⁻¹)	Cumulative yield (kg tree ⁻¹)	Yield efficiency (kg cm ⁻²)
Cultivar	Rootstock		Year-2008	2006-2008	
E-101	Evrica	101.3 c	13.6 a	21.6 a	0.13 a
	KRYMSK 86®	53.7 a	11.4 a	22.2 a	0.21 b
	PAC 00-08	71.6 b	13.6 a	22.5 a	0.19 ab
	PADAC 01-47	92.4 c	23.1 b	37.4 b	0.26 c
	Torinel	106.4 c	15.9 ab	28.7 ab	0.15 a
E-404	Evrica	103.9 b	20.6 b	25.5 a	0.20 b
	KRYMSK 86®	72.4 a	11.0 a	18.8 b	0.15 a
	PAC 00-08	60.1 a	13.3 a	19.3 b	0.23 b
	PADAC 01-47	75.7 a	23.4 b	33.2 c	0.32 c
	Torinel	70.9 a	15.8 b	22.0 ab	0.22 b

449 For each cultivar, mean separation within columns by LSD test at ($P \leq 0.05$).

450 TCSA: Trunk cross-sectional area.

451

452 Table 4. Effect of rootstock on fruit quality of ‘E 101’ and ‘E-104’ apricot cultivars, in the fourth (2008) year after grafting.
 453

Cultivar	Rootstock	Fw (g)	Ø e (mm)	Ø s (mm)	Ø p (mm)	Sp	Pt (mm)	Sw (g)	FF (kg cm ⁻²)	Py (%)	SSC (°Brix)	TA	SSC/TA
E-101	Evrica	61.3 c	47.3 c	45.4 c	47.7 c	1.01 a	13.4 b	2.9 b	1.8 bc	95.0 b	10.6 a	19.3 a	5.9 a
	KRYMSK 86®	60.4 c	45.5 bc	45.9 bc	47.3 bc	1.04 b	14.1 cd	3.1 c	2.1 c	94.8 b	10.2 a	22.8 a	4.9 a
	PAC 00-08	51.3 b	44.4 b	44.2 ab	46.2 bc	1.04 b	13.8 bc	2.4 a	3.1 d	94.9 b	10.0 a	19.6 a	5.5 a
	PADAC 01-47	44.8 a	42.0 a	42.5 a	44.0 a	1.05 b	12.6 a	2.5 a	1.5 ab	94.1 a	12.6 b	21.3 a	6.3 a
	Torinel	56.7 c	46.4 c	46.7 c	46.1 b	0.99 a	14.5 d	3.2 c	1.2 a	95.0 b	11.0 ab	18.2 a	6.1 a
E-404	Evrica	71.1 b	48.4 c	49.9 bc	51.9 b	1.06 a	14.1 ab	2.4 a	2.2 a	95.4 a	12.2 ab	16.5 a	7.5 a
	KRYMSK 86®	72.7 b	48.7 c	51.2 c	51.3 b	1.06 a	14.6 ab	2.4 a	2.6 a	95.9 b	13.1 c	16.5 a	7.9 a
	PAC 00-08	71.5 b	47.2 bc	50.5 bc	51.5 b	1.09 b	14.7 b	2.7 b	3.4 b	95.7 ab	11.5 a	17.7 a	6.5 a
	PADAC 01-47	57.0 a	43.7 a	47.0 a	48.8 a	1.12 c	14.0 a	2.4 a	4.4 c	95.7 ab	13.0 bc	20.3 a	6.8 a
	Torinel	65.9 b	46.2 b	48.9 ab	50.7 ab	1.10 bc	14.4 ab	2.5 a	3.2 b	95.6 ab	11.5 a	17.1 a	6.7 a

454 For each cultivar, mean separation within columns by LSD test at ($P \leq 0.05$).

455 Abbreviations: Fw: fruit weight; Øe: equatorial diameter; Øs: suture diameter; Øp: polar diameter; Sp: sphericity; Pt: pulp thicknes; Sw: stone
 456 weight; FF: flesh firmness; Py: % pulp yield; SSC: soluble solid content; TA: titratable acidity.

457 Table 5. Effect of rootstock on chromatic parameters of ‘E 101’ and ‘E-104’ apricot cultivars in the fourth (2008) year after grafting.

		L*	a*	b*	H°	C*
Cultivar	Rootstock					
E-101	Evrica	63.3 b	15.4 a	48.3 c	71.5 b	52.0 b
	KRYMSK 86®	58.4 a	20.4 b	42.0 a	63.8 a	47.9 a
	PAC 00-08	59.9 a	13.9 a	43.9 ab	71.7 b	47.4 a
	PADAC 01-47	60.5 ab	21.1 b	46.0 bc	64.9 ab	51.4 b
	Torinel	61.4 ab	17.6 ab	43.8 ab	67.3 ab	48.7 a
E-404	Evrica	56.7 b	26.0 b	41.9 c	57.2 ab	50.8 b
	KRYMSK 86®	55.1 b	25.9 b	40.4 bc	56.4 ab	49.8 b
	PAC 00-08	50.6 a	25.1 ab	33.1 a	51.6 a	44.1 a
	PADAC 01-47	50.8 a	25.7 b	35.5 ab	53.2 ab	45.6 a
	Torinel	54.0 ab	20.8 a	39.1 bc	60.8 b	45.8 a

458 For each cultivar, mean separation within columns by LSD test at ($P \leq 0.05$).

459 L*= lightness; a*= redness and greenness; and b*= yellowness and blueness; H° = hue value = $\arctg(b^*/a^*)$ and C* = colour

460 intensity $\sqrt{a^{*2} + b^{*2}}$

461 Table 6. Correlations among fruit quality parameters in ‘E-101’ and ‘E-104’ apricot cultivars for physical and biochemical traits, vigour and
462 yield characteristics.

	Fruit weight	Flesh firmness	Pulp yield	TA	SSC	SSC/TA	TCSA	Yield	Cumulative yield	Yield efficiency
Fruit weight	1									
Flesh firmness	ns	1								
Pulp yield	0.5446	ns	1							
TA	ns	ns	ns	1						
SSC	ns	-0.5017	0.4545	ns	1					
SSC/TA	ns	ns	ns	-0.9532	ns	1				
TCSA	-0.3969	ns	-0.5054	ns	ns	ns	1			
Yield	ns	ns	-0.3217	0.5211	ns	-0.5721	0.3301	1		
Cumulative yield	ns	ns	ns	ns	ns	-0.3210	0.3319	0.5357	1	
Yield efficiency	ns	ns	ns	ns	0.3245	ns	-0.3521	ns	0.5792	1

463 Significant at $P \leq 0.05$; ns: not significant