

Original Research Article

The Effect of Different Pear Rootstocks on the Performance of Pear Cultivars Grown in Semi-Arid Climatic and High Calcareous Soil Conditions

ABSTRACT

Rootstocks in fruit growing affect the performances of the cultivated varieties which have been overgrown, such as tree growth, yield, earliness, fruit quality, flowering, fruit setting, content of nutrients in leaves and fruits. In this study, in summer very high temperatures seen in the GAP Region (Sanliurfa-Turkey), and high lime soil conditions with a ratio in wild quince seedling, clonal quince A (*Cydonia oblonga* Mill.) and BA 29 (*Cydonia oblonga* Mill.) some pear cultivars budded on rootstocks performance was studied. In the study, some pomological and phenological characteristics of 6 pear cultivars (Abbe Fetel, Akça, Bella di Giugno, Coscia, Deveci, and Dr. Jules Guyot) planted in 2004 in Sanliurfa conditions were determined. Bud swell and bud bursting occurred on different rootstock in March, and flowering occurred in April. Among the pear cultivars, the earliest flowering cultivar of pear is Akça (27 March), while the earliest fruit ripen variety is Bela di Giugno (01 July). Among the varieties, The latest variety for fruit ripening has been identified as Deveci. Among the pear varieties studied, the heaviest (451.16 g), the widest (92.28 mm) and the largest volume (428.39 cm³) of fruits were Deveci on the clonal Quince A rootstock, while the longest fruit was Abbe Fetel (114.64 mm) and the highest fruit flesh firmness was determined Deveci cultivar (19.22 kg/cm²) budded on seedling rootstock. The total soluble solid matter content in the cultivars varied from 13.50-15.95% and the titratable acid content varied from 0.33-0.56%.

Keywords: Pear, pear rootstocks, *Pyrus communis* L., *Cydonia oblonga*, BA 29, pear phenology, pear pomology

1. INTRODUCTION

Anatolia is one of the main gene centers of pear which spread in a wide region over the world from Middle Eastern Europe to Anatolia, Caucasia and Turkistan. It is reported that there are more than 600 kinds of pears in Anatolia [1-2]. Pear, which is more sensitive to cold weather than apple, has spread to wide regions in the world. The most important factor limiting pear cultivation is the late spring frosts. Pear is more resistant to high temperatures and drought than apples. Pears can grow up to 55° latitude in the northern hemisphere [2].

In order to increase pear cultivation in many countries in the world, researches are being carried out on a variety of pears in order to determine whether the varieties are suitable to

cultivate in that region. It is highly necessary to ensure the introduction of various kinds of promising pear cultivated in the world and found in different provinces or regions in our country to different regions of our country and to determine their adaptation situations in different ecologies.

The time and duration of developmental stages of a fruit cultivar varies depending on the region and the location. It is not possible to apply the results of the phenological observations made for the determination of the developmental stages of the plants to all the regions or locations where fruits are planted. The ecology of the region, i.e. environmental conditions, has a great effect on phenological observations. Therefore, in order to determine suitable varieties for a region, it is necessary to carry out researches in that region. Researches on varieties to be carried out in the region where fruit growing or fruit cultivars are thought to be extended are often not sufficient. Identification of suitable rootstocks for varieties in the same region, that is to say, determination of the suitable rootstock for the region, is also very important.

Although Sanliurfa province has suitable ecological conditions for many fruit types or varieties, pistachios are grown alone as the leading product. The number of almond, olive, pomegranate and apricot covered gardens has increased significantly in recent years. In addition to these types, there are also apple and pear gardens. Apple and pear are mostly grown as hobby gardening to meet family needs. In this study, the phenological and pomological characteristics of some native and foreign pear varieties that have been planted to different rootstocks in the ecological conditions of Sanliurfa have been determined and it is aimed to produce these varieties in the future.

2. MATERIAL AND METHODS

2.1. Site description

The experiment was carried out at the Harran University Pome Fruit Research Station in Sanliurfa, Turkey (37°10' N, 38°59' E; alt. 520 m) during 2013-2014. Sanliurfa province has semi-arid climate features with cold and wet during the winter and very hot and dry in the summer seasons. During the experiment, the air temperatures were in average 29.9 °C in summer and 9.4 °C in winter, while annual precipitation ranged between 355-447 mm, mainly concentrated between the months of November and April (Figure 1). The average relative humidity is at the level of 52.2%. Relative humidity is the highest (66%) ratio in January and in July is the lowest (36%) level. The orchard was established in a calcareous (21.5% total carbonates and 10.7% active lime), alkaline and clay-loam textured soil. The physical and chemical characteristics of the soil were clay 58.5%, silt 18.5% and sand 21%, with the low level of organic matter (1.16%), pH 7.92 (in 1M KCl), and optimum concentrations of available P (80 mg kg⁻¹), K (160 mg kg⁻¹), Mg (50 mg kg⁻¹), and Fe (DTPA-extractable Fe:1.45 mg kg⁻¹) in the top soil layer (0–40 cm).

2.2. Plant material and experimental design

Experiment was carried out on 8-years old (tree spacing 5 x 5 m) 'Akça', 'Coscia', 'Deveci' and 'Dr. Jules Guyot' on wild quince seedlings (*Cydonia oblonga* Mill.), 'Abbe Fetel' on BA 29 (*Cydonia oblonga* Mill.), and Bella di Giugno and Deveci pear cultivars on quince A (*Cydonia oblonga* Mill.) rootstocks. All pear trees were planted at 5 x 5 m (400 trees ha⁻¹) distance in December 2004 with 1-year-old scions and trained as a central leader system.

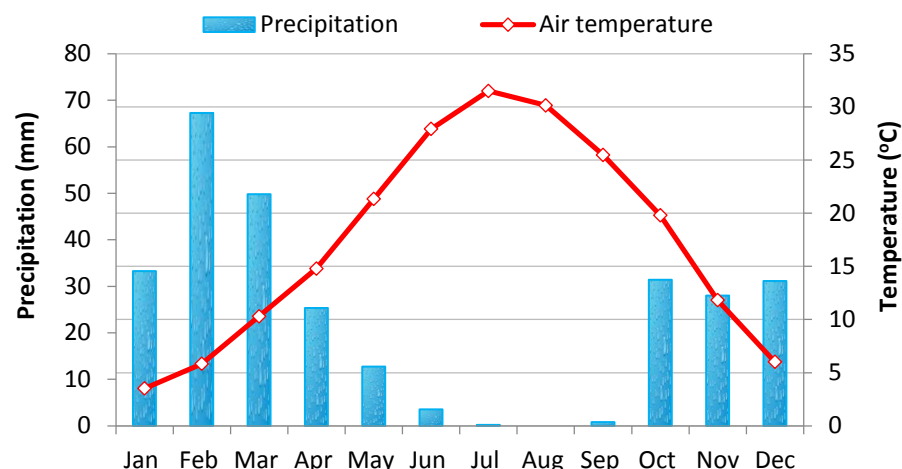


Fig. 1. Seasonal temperature and rainfall patterns of the experimental orchard

2.3. Cultural treatments

Irrigation of the orchard was carried out using a computerized drip irrigation system. Irrigation frequency was two times per week from May to October each season according to regional recommendations using class-A pan. Each treatment (tree) received the same total amount of water in each season. All treated trees were similarly fertigated with essential minerals using the fertigation method. No foliar application of nutrients was made to these trees. Thinning of flowers or fruitlets was not carried out during the experiment. Weed, disease, and insect control was managed using the practices that were commonly used for commercial production, and all the treatments were under the identical management. A copper spray was put on at budbreak to protect the trees from fireblight.

2.4. The phenological observations

Bud swelling, bud burst, beginning of flowering, full bloom, end of flowering, and harvesting times of the fruits were determined.

2.5. Data collection on fruit quality characteristics

Some pomological features of cultivars were also evaluated by measuring of fruit weight (g), fruit diameter (mm), fruit length (mm), fruit volume (cm^3), fruit firmness (lb cm^{-2}), total soluble solids (TSS) (%), pH and titratable acidity (TA) (%). For the analyses of fruit quality characteristics, the total fruit was graded according to size. Ten fruit from the bulk group were taken as a representative sample for further analyses. The important fruit traits such as individual fruit weight, fruit diameter, fruit length, fruit volume, flesh firmness etc. were measured. Fruit flesh firmness was measured on opposite sides of the fruit with skin removed by using Effegi penetrometer (model. FT-327; McCormick Fruit Tech, Yakima, WA) with an 11 mm diameter tip and expressed in terms of lb force. The total soluble solids (TSS) (%) was measured with a hand Atago refractometer (expressed as %). Titratable acidity of fruit juice was measured by titrating fruit juice against 0.1N NaOH at pH 8.1 and was expressed as percent malic acid.

3. RESULTS AND DISCUSSION

According to the results of phenological observations made on different pear varieties planted on different rootstocks between 2013 and 2014, while bud swell and bud burst in pear varieties occurred in March, the first flowering (except for the Akça cultivar), complete flowering and end of flowering occurred in April (Table 1).

In the pear varieties used in the experiment, bud swelling occurred between March 5 and March 14, bud burst occurred between March 13 and March 20, first flowering occurred between March 27 and April 5, full flowering occurred between April 5 and April 11 and the end of flowering occurred between April 11 and April 16.

When the varieties in terms of harvest dates were examined, it was observed that the Bella di Giugno ripened the earliest (July 1) and the Deveci ⁽¹⁾ ripened the latest (November 16) and the harvest dates of other varieties were between these two varieties.

Table 1. Phenological observation results of some pear varieties budded on different rootstocks (2013-2014)

Cultivars	Bud swelling	Bud burst	First bloom	Full bloom	End of flowering	Fruit maturation
Akça ⁽¹⁾	8 March	13 March	27 March	5 April	11 April	22 July
Coscia ⁽¹⁾	13 March	16 March	3 April	9 April	15 April	8 August
Deveci ⁽¹⁾	14 March	20 March	5 April	11 April	16 April	16 Nov.
Dr. Jules Guyot ⁽¹⁾	13 March	16 March	4 April	9 April	15 April	17 Sept
Abbe Fetel ⁽²⁾	5 March	13 March	1 April	6 April	11 April	16 Oct.
Bela di Giugno ⁽³⁾	13 March	16 March	1 April	7 April	13 April	1 July
Deveci ⁽³⁾	13 March	20 March	4 April	10 April	16 April	13 Nov.

⁽¹⁾: Budded on quince seedling, ⁽²⁾: Budded on BA 29 rootstock, ⁽³⁾: Budded on Quince A rootstock.

In his research carried out in order to determine the suitable domestic and foreign pear varieties to the Aegean Region, Ercan [3] tested 18 cultivars of pear in Aegean Agricultural Research Institute. According to the results of the phenological observations made on the experimental varieties, bud swelling occurred between March 1 and March 3, bud burst occurred between March 20 and March 25, the first flowering 16 March- 1 April, full flowering 27 March- 15 April and the end of flowering 26 March-22 April. The varieties were harvested in a period of 4 months between June and September.

In Akca and Deveci pear varieties grown in Diyarbakir conditions, bud swelling occurred between March 20 and March 22, first flowering on April 9 and April 11, full flowering on April 16 and April 21, and fruit ripening on July 24 and September 3 respectively [4].

Akçay et al. [5] reported that in Yalova conditions, the Akça pear cultivar reached the harvest stage in the first week of July and the Deveci cultivar reached the harvest stage in the first half of October.

Ertürk et al. [6] used varieties of Beurre Precoc Morettini, Coscia, Deveci, Santa Maria and Williams planted on quince A in the study they carried out in order to determine pear varieties suitable to the conditions of Ispir district of Erzurum province. According to the results of the phenological observations on the varieties used in the experiment between 2005 and 2008, it was determined that the bud swelling occurred between April 2 and April

148 17, full flowering between April 23 and May 7, and harvest dates were between August 24
149 and November 4.

150 The fruit characteristics of varieties are given in Table 2 and Figure 2. In terms of fruit
151 weight, Deveci/Quince A pear cultivar was the first with 451.16 g, while this variety was
152 followed by Dr. Jules Guyot with 335.70 g., Deveci/quince seedling with 305.81 g and Abbe
153 Fetel with 300.14 g. The Bela di Giugno variety is the smallest pear with 74.22 g.

154 Significant differences were also found between fruit varieties in terms of fruit width
155 measurements. The highest value was found in the Deveci/Quince A variety with 92.28 mm
156 and the lowest value was found in the Bela di Giugno range with 50.80 mm. When the fruit
157 height values were examined, the highest fruit size was measured at 114.64 mm in the Abbe
158 Fetel variety and the lowest fruit size was measured in the Bela di Giugno with 76.58 mm.

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Table 2. Pomological characteristics of pear varieties

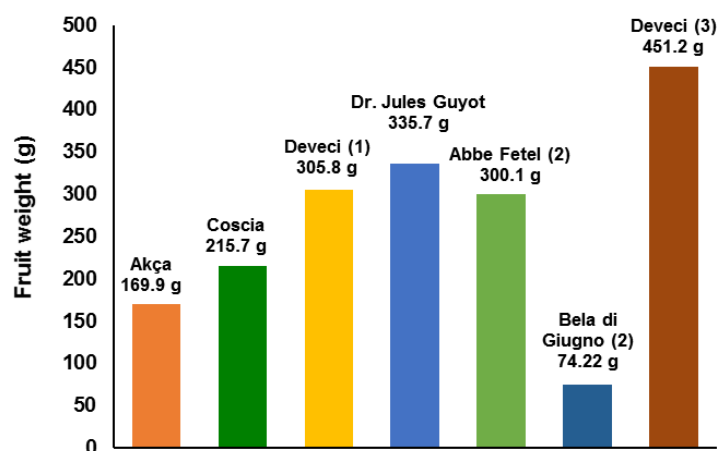
Cultivars	Average fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Average fruit volume (cm ³)	Fruit flesh firmness (lb cm ⁻²)	TSS (%)	pH	TA (%)
Akça ⁽¹⁾	169.93 de	63.09 d	82.33 bc	179.22 c	10.61 cd	15.95	3.66	0.33
Coscia ⁽¹⁾	215.71 cd	69.53 cd	88.49 bc	218.47 c	13.88 bc	13.50	4.38	0.56
Deveci ⁽¹⁾	305.81 bc	81.34 ab	83.53 bc	316.44 b	19.22 a	15.85	3.72	0.33
Dr. Jules Guyot ⁽¹⁾	335.70 b	78.13 bc	109.47 a	349.08 b	12.60 cd	14.55	3.64	0.36
Abbe Fetel ⁽²⁾	300.14 bc	77.02 bc	114.64 a	309.78 b	7.90 d	15.30	4.50	0.34
Bela Di Guigno ⁽³⁾	74.22 e	50.80 e	76.58 c	76.82 d	7.71 d	14.70	4.36	0.52
Deveci ⁽³⁾	451.16 a	92.28 a	92.21 b	428.39 a	18.00 ab	15.25	3.83	0.41

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⁽¹⁾: Budded on quince seedling, ⁽²⁾: Budded on BA 29 rootstock, ⁽³⁾: Budded on Quince A rootstock.



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Fig. 2. The average fruit weight values of the pear varieties budded on different rootstocks

169 The highest volume of fruit was in Deveci /Quince A with 428.39 cm³ and this variety was
170 followed by Dr. Jules Guyot, Deveci/quince seedling and Abbe Fetel/BA 29 with 349.08,
171 316.44 and 309.78 cm³ respectively. The lowest fruit volume was determined in Bela di
172 Giugno with 76.58 cm³.

Significant differences were also found between fruit varieties in terms of fruit hardness values (Table 2, Figure 3). The highest value was found in with Deveci/quince seedling with 19.22 lb cm⁻² and the lowest value was found in Abbe Fetel and Bela di Giugno (7.90 and 7.71 lb cm⁻² respectively).

No statistically significant differences were found among pear varieties in terms of TSS matter, pH and titratable acid content. The highest amount of water-soluble dry matter was in Akça with 15.95%, followed by Deveci/ pear seedling with 15.85% and Abbe Fetel with 15.30%. The lowest TSS was found in the Coscia cultivar with 13.50%. The pH values of the pear varieties used in the experiment were found between 3.64 (Dr. Jules Guyot) and 4.50 (Abbe Fetel). The highest titratable acidity value in terms of the malic acid was in Coscia with 0.56%, while the lowest acidity was determined in the varieties of Akça and Deveci/pear seedling with 0.33%.

In his study conducted on 18 pear cultivars in İzmir in order to determine suitable domestic and foreign pear varieties to the Aegean Region, Ercan [3]determined the fruit weight of the varieties Abbe Fetel, Akça, Coscia, Dr. Jules Guyot he used in his study as 194.6, 54, 128.2, 244.3 g, the fruit width as 60.0, 44.8, 54.3, 72.9 mm, the fruit size as 97.9, 61.7, 71.4 and 85.6 mm, the fruit hardness as 1.3, 9.4, 8.9, 8.5 lb/cm² and the TSS as 14.2, 11.5, 10.0 and 11.5 % respectively.

In a survey carried out on a total of 15 pear varieties in the Southeast Anatolia Region between 1985 and 1993, the average fruit weights of Akça and Deveci varieties were 67.3 g and 257.2 g, fruit width 47.0 mm and 72.3 mm, fruit size 60.8 and 99.2 mm, total soluble solids matter (TSS) was determined to be 15.3% and 17.3% [4].

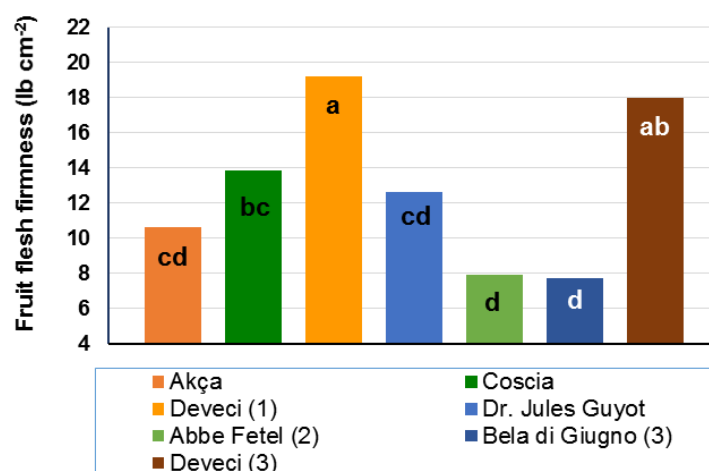


Fig. 3. Average fruit firmness values of pear varieties

In the "Pear Introduction and Adaptation Experiment" conducted by Akçay et al. [5] at Ataturk Horticultural Central Research Institute, the average fruit weights for Akça and Deveci which we used in our experiment were determined as 58.39 and 323.49 g, the fruit width was 42.61 and 75.40 mm, the fruit size was 56.30 and 80.98 mm, the fruit hardness was 4.34 and 6.10 kg/cm², the TSS was 14.06 % and 13.40 % and the amount of titratable acid 0.23 % and 0.30 % respectively.

In the experiment conducted on 6 years old 'Deveci' pear (*Pyrus communis* L.) varieties planted on Quince A rootstock under the conditions of Egirdir (Isparta-Turkey), Canlı et al. [7] determined the fruit weight as 300.46 g, the fruit diameter as 82.04 mm, the fruit size as

209 86.66 mm, the fruit hardness as 21.87 lb, TSS as 14.05%, pH as 4.39 and titratable acidity
210 as 0.13 %.

211 In a study conducted to determine pear varieties suitable for Ispir (Erzurum) district
212 conditions, the highest average fruit varieties were in Deveci (302.25 g) and the lowest were
213 in B.P. Morettini (174 g) [6]. The fruit width of the varieties used in the same study varied
214 between 58.5 mm (B.P. Morettini) to 81.5 mm (Deveci); the fruit size varied between 80.5
215 mm (B.P. Morettini) and 100 mm (Santa Maria). The TSS amount, fruit juice pH values, the
216 total sugar content varied between 17.87% (Coscia) and 21.75% (Santa Maria), 4.03
217 (Coscia) and 4.28 (Santa Maria) and 8.87% (Williams) and 11.75% (Deveci) respectively. In
218 terms of fruit hardness, the highest value was found in Deveci (6.25 kg) while the lowest
219 value was found in Coscia (5.15 kg) [6].

220 Kılıç and Bostan [8] examined the fruit and tree characteristics of 23 local pear varieties
221 grown in Gürgentepe district of Ordu province. The fruit weight varied between 36.23 and
222 146.65 g, fruit width between 41.43 and 65.25 mm, fruit size between 41.37 and 74.75 mm,
223 fruit volume between 49.50 and 170.55 cm³, fruit hardness between 4.29 and 9.36 kg, pH
224 value in fruit juice between 3.76 and 4.78, TSS between 6.59 % and 15.38 % and the
225 amount of titratable acidity varied between 1.73 and 15.53 %.

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228 **4. CONCLUSION**

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230 The reason why phenological and pomological results obtained in this study differed from the
231 values obtained from the studies carried out for some local and foreign pear varieties in
232 different ecological conditions may be due to the differences in the varieties used,
233 differences in the tree age, differences in the rootstocks on which the varieties were planted,
234 the ecological conditions of the cultivation area, differences in caring methods (irrigation,
235 pruning, fertilizing, tillage etc.), whether dilution has been realized or not, differences in the
236 agricultural pesticides used and even if the same pesticide was used, may be due to the
237 differences in the harvest dates.

238 The Bella di Giugno variety from the varieties used in our research stands out as the earliest
239 ripening variety. Ripening in a time when there are no pears sold in bazaars or markets, this
240 pear variety is sold for 2-3 TL for 1 kg although it constitutes a small proportion of the fruits in
241 Sanliurfa conditions. Even the Akça variety, which ripens 20 days after Bella di Giugno, is
242 sold for very good prices in Sanliurfa market. If the other pear varieties which ripen later than
243 these varieties are grown in sufficient amounts to meet the needs of the provinces in the
244 region, we think that there will not be any problem of marketing them.

245 As a result of this study, it was determined that the Deveci pear variety of Sanliurfa ecology
246 can be grown as high quality as the Marmara, Aegean, Mediterranean and Central Anatolia
247 regions. The Deveci pear, which will be grown in the closed pear gardens to be installed in
248 high altitude highlands of Sanliurfa (Siverek, Hilvan, Bozova), will be a kind of fruit which will
249 be sold all over Sanliurfa and the neighboring provinces in the future and will provide higher
250 income for pear producers with the increasing of storage possibilities.

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253 **COMPETING INTERESTS**

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255 Authors have declared that no competing interests exist.

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