Effect of Several Peach × Almond Hybrid Rootstocks on Fruit Quality of Peaches

E.S. Albás[1], S. Jiménez[1], J. Aparicio[1], J.A. Betrán[2] and M.A. Moreno[1]
[1]Department of Pomology, Estación Experimental de Aula Dei (Consejo Superior de Investigaciones Científicas), Apartado 202, 50.080 Zaragoza, Spain
[2]Laboratorio Agroambiental (Diputación General de Aragón), Apdo. 727, 50.071 Zaragoza
Spain

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Abstract

The influence on fruit quality of peach × almond hybrids 'Adafuel', 'Adarcias' and 'GF 677', as rootstocks for 'Catherina' peach cv. and 'Flavortop' nectarine cv. were tested in two trials. The experiment was performed in the Ebro Valley, on a heavy and calcareous soil. To evaluate fruit quality, parameters such as fruit size, fruit weight, colour, firmness and some chemical properties of the fruit (acidity, pH and soluble solid concentration) were measured. In addition, the most important sugars found in fruit juice (sucrose, glucose, fructose and sorbitol) were analysed by High Performance Liquid Chromatography (HPLC). Significant differences in sugar concentrations, colour parameters, fruit weight and size were found among rootstocks. Nevertheless, no differences were shown for firmness. Preliminary results indicate that 'Adarcias' rootstock induces the highest soluble solid concentrations.

INTRODUCTION

For optimal orchard production it is essential that the size, organoleptic characteristics and nutritional composition of the fruit should be adequate. In general, the influence of rootstocks on the vigour and yield of the cultivar has been well demonstrated in the published literature. However, few studies address the quality characteristics of the fruit in relation to tree condition and rootstock influence. The study of this influence is a novel aspect.

The present field test was carried out over three years with 'Catherina' peach and 'Flavortop' nectarine grafted on peach x almond hybrid rootstocks, grown on calcareous soil conditions. The objective was to determine the relative influence of the rootstock on fruit quality parameters such as fruit size, fresh weigh, colour, firmness and some chemical fruit properties (acidity, pH and soluble solid content).

MATERIAL AND METHODS

Plant Material

The rootstocks under study included three peach × almond hybrid selections: 'Adafuel', 'Adarcias' and 'GF 677'. All were grafted in situ with 'Catherina' peach and 'Flavortop' nectarine in April of 1983.

Trial Characteristics

The trial was carried out at the Estación Experimental de Aula Dei (Zaragoza, Spain) on a calcareous soil, with 33% total calcium carbonate, 8% active lime, pH in water 8.4, and a clay-loam texture.

Yield and Fruit Characteristics

Besides yield (Kg/tree), mean fruit weight (g), vigour [through the calculation of the trunk cross-sectional area (TCSA) from the measure of the cultivar trunk circumference 20 cm above the graft], yield efficiency (Kg cumulative yield/cm^2 of

TCSA) and fruit quality characteristics were analysed. For 1999, 2000 and 2001, mean fruit weight, soluble solids content (SS), pH and acidity were recorded.

In 2001, 50 fruits from each tree were randomly selected at harvest, to estimate fruit quality. Several physical-chemical parameters were considered, such as colour, acidity, pH and firmness. The SS concentration, pH and the acidity was also considered as organoleptical properties.

In 1999, 2000 and 2001, yield, mean fruit weight and size were recorded. Size was determined by a digital slide gauge (Mitutoyo DL-10): polar diameter (∅P), suture diameter (∅S) and equatorial diameter (∅E). This terminology was proposed by Caillavet y Souty (1950).

In all these years, 15 fruits from each tree were randomly selected, to estimate fruit quality. Several physical-chemical parameters were considered, such as colour, acidity, pH and firmness. The total solid soluble content (SSC), pH and acidity were also considered as organoleptic properties.

Concentration of solid soluble content (ºBrix) was measured using an Atago PR-101 digital refractometer from fruit juice extracted from each sample. Titratable acidity (TA) was determined on a sample of juice from 15 fruits. The juice samples were diluted with distilled water (1:10), and microtitrated with 0.1 $mol \cdot l^{-1}$ NaOH. The fruit colour was measured with a Minolta colorimeter (Minolta, CR-200, Japan). For each sample, values from parameters L*, a*, b*, C* and H* were assigned. Firmness was estimated by a penetrometer. The ripeness index was calculated based on the SS concentration/acidity ratio (Ferrer, 1998).

Sugar Analysis

The fruit juice was first extracted. Soluble sugars of 1 ml juice, were then fixed for 15 min with 1 ml ethanol/water (80:20, v:v) at 80ºC after which the mixture was centrifuged (3600g for 15 min). The supernatant was used for analysis of soluble sugars.

Soluble sugars were purified using ion exchange resins (Bio-Rad AG 1-X4 Resin 200-400 chloride form, Bio-Rad AG 50W-X8 Resin 200-400 mesh hydrogen form) (Moing et al.,1992). The samples were concentrated to 1ml and analysed by high-performance liquid chromatography (HPLC) using a Ca-column (Aminex HPX-87C 300 mm × 7.8 mm column Bio-Rad) flushed with 0.6 $ml \cdot min^{-1}$ deionized water at 85ºC with a refractive index detector (Waters 2410). Twenty microliters of sample was injected.

Concentrations of sucrose, fructose, glucose and sorbitol were analysed for each tree. Manitol was included in the sum of sugars as an internal standard.

Sugar quantification was carried out with Millennium 3.2 software from Waters (Milford, Mass). HPLC peaks were identified using commercial standards. Peak areas were calculated, and calibration was carried out using external standards of known quantities of sugars from Panreac Quimica S.A. Standard solutions were prepared in water.

RESULTS AND DISCUSSION

Annual and Cumulative Yield

Tree vigour was significantly lower on ‘Adarcias’ than on the other rootstocks when grafted with ‘Catherina’ (Table 1). ‘Flavortop’ trees on ‘Adafuel’ showed the highest vigour. The tendency of ‘Adarcias’ towards lower vigour has been already described (Moreno et al., 1994; 1995). On the other hand, ‘Adafuel’ induced a similar or higher level of vigour than ‘GF 677’, although the latter rootstock is generally recognized as one inducing high vigour.

The cumulative yield of ‘Catherina’ showed no significant differences associated with rootstocks. However, for ‘Flavortop’, the cumulative yield was significantly higher on ‘Adafuel’ and ‘GF 677’ than on ‘Adarcias’. A clear tendency for the most vigorous rootstocks to produce higher values of cumulative yield was observed. For ‘Flavortop’ a positive correlation was found between cumulative yield and vigour in all years under

study: 1999 (r=0.80; $p \leq 0.01$), 2000 (r=0.83; $p \leq 0.01$) and 2001 (r=0.81; $p \leq 0.01$). Nevertheless, the absence of any similar correlations for 'Catherina' shows that on some cultivars this relationship between vigour and cumulative yields is much poorer.

No significant differences for yield efficiency were found for 'Catherina' on any rootstock. Despite the highest cumulative yields being harvested from trees on 'Adafuel' and 'GF 677', their higher vigour tended to decrease their yield efficiency, as previously reported (Moreno et al., 1994; 1995). For 'Flavortop', 'GF 677' rootstock induced higher yield efficiency than 'Adafuel', largely because of its lower vigour.

Weight and Size

The mean fruit weight on 'Catherina' showed significant differences among rootstocks in 2001 (Table 2). 'Adafuel' induced larger fruits than 'Adarcias'. However, differences were not found with 'GF 677'. For 'Flavortop', differences were not statistically significant among the rootstocks. In a previous report (Moreno et al., 1994), 'Adafuel', the most vigorous rootstock, produced higher mean fruit weight.

In relation to size, 'Adafuel' induced larger fruit equatorial diameter (∅E) than Adarcias when grafted with 'Catherina', as occurred in 2001 with 'GF 677' when grafted with 'Flavortop' (data not shown). Significant differences were not found among rootstocks for the ∅P/∅S and ∅E/∅S ratios.

Colour

This is considered an important measurement, since the refractance spectrum has been proposed as a ripeness index. In addition, the colour is important for the market acceptance by the consumer (Grigelmo and Martín, 2000).

'Catherina' trees on 'GF 677' induced a darker red skin than 'Adafuel' and 'Adarcias'. This result was evidenced by the differences in the a* coordinate, in the system L* a* b*, and in the coordinate H*, in the system L* C* H* (Table 3). This result only appeared in 2001. In that year, the purpose was to determine if an anticipated harvest had an influence over fruit quality. 'Flavortop', when worked on 'GF 677' rootstock, induced less intense coloured fruits (higher L*) than when grafted on 'Adarcias', although significant differences were not found in the 2000 harvest.

Soluble Solids Concentration

'Catherina' grafted on 'Adarcias' induced a higher SS concentration than when grafted on 'Adafuel' or 'GF 677', in 1999 and 2001 (Table 4). This tendency was also found in 2000, although differences were not significant, as happened with 'Flavortop' trees.

On the other hand, a negative correlation was found between the SS concentration and the cumulative yield. For 'Catherina', the correlation was observed in the three years under study: 1999 (r=-0.53; $p \leq 0.05$), 2000 (r=-0.70; $p \leq 0.05$) and 2001 (r=-0.59; $p \leq 0.05$). For 'Flavortop', the correlation was also observed in the three years: 1999 (r=-0.54; $p \leq 0.05$), 2000 (r=-0.64; $p \leq 0.05$) and 2001 (r=-0.49; $p \leq 0.05$).

Sugar Analysis by HPLC

In fruits from the 2001 harvest, the concentration of major sugars was determined. Sacarose was the sugar at highest concentration, ranging between 65 and 80% of the total, followed by glucose (9-21%), fructose (3-25%) and sorbitol (4-11%). These concentrations seem to be usual in peach (Dirlewanger et al., 1999). The sugar concentration was influenced by both rootstocks and cultivars (Table 5).

With both cultivars, 'Adarcias' rootstock induced higher sacarose concentration than 'Adafuel'. 'GF 677' showed an intermediate situation and did not differ from the other two rootstocks. 'Catherina' grafted on 'GF 677' showed a tendency to induce a greater concentration of fructose in fruits than 'Adarcias', although both did not differ significantly from 'Adafuel'. No differences were found among rootstocks for the glucose and sorbitol concentrations.

Titratable Acidity and pH

No significant differences were found among rootstocks for the fruit pH. With 'Catherina', 'Adarcias' rootstock induced greater acidity than 'Adafuel' and 'GF 677', in 1999 (Table 6). In 2000, 'Adarcias' induced higher acidity than 'GF 677', although these two did not differ significantly from 'Adafuel'. In 2001, 'Adarcias' also induced higher acidity than 'Adafuel'. With 'Flavortop', no significant differences were found among rootstocks.

Firmness

During the course of this study, no significant differences were found among rootstocks in terms of fruit firmness.

Ripening Index

For 'Catherina', no significant differences were found among rootstocks on the fruit ripening index (SS/TA) (Table 7). Despite the fact that 'Adarcias' induced a higher significant SS concentration, no differences were found between the rootstocks in terms of the fruit ripening index, because the acidity was high. However, for 'Flavortop', a tendency of 'Adarcias' to induce greater SS/TA than 'Adafuel' (1999's harvest) and 'GF 677' (2001's harvest) was observed.

CONCLUSION

'Adarcias' induced to better fruit organoleptic quality (higher SS concentration and/or sugars than 'Adafuel' and 'GF 677'), especially when grafted with 'Catherina'. In addition, a higher ripening index was not found on trees of 'Catherina' on 'Adarcias', which could explain the greater SS concentration. No significant differences were found in terms of firmness that could have been attributed to a higher ripening index of the fruits.

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Tables

Table 1. Rootstock effect on vigour and yield of peach cultivars after 18 years in the orchard.

Cultivar	Rootstock	TCSA (cm^2)	Cumulative yield (Kg/tree)	Yield efficiency (Kg/cm^2)
Catherina	Adafuel	494 b	565 a	1.14 a
	Adarcias	355 a	498 a	1.40 a
	GF 677	457 b	598 a	1.31 a
Flavortop	Adafuel	522 b	761 b	1.46 a
	Adarcias	306 a	504 a	1.66 ab
	GF 677	388 a	713 b	1.84 b

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 2. Rootstock effect on mean fruit weight of peach cultivars.

		Mean fruit weight (g)		
Cultivar	Rootstock	1999	2000	2001
Catherina	Adafuel	154 a	162 a	195 b
	Adarcias	163 a	166 a	177 a
	GF 677	161 a	166 a	178 ab
Flavortop	Adafuel	165 a	190 a	187 a
	Adarcias	169 a	180 a	191 a
	GF 677	174 a	178 a	194 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 3. Rootstock effect on fruit colour of peach cultivars.

		L*		a*		b*		C*		H*	
Cultivar	Rootstock	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Catherina	Adafuel	65.6 a	67.4 a	18.2 a	-19.5 a	55.0 a	40.5 a	58.0 a	45.0 a	71.5 a	115.7 b
	Adarcias	56.0 a	67.2 a	16.6 a	-19.6 a	47.6 a	40.1 a	50.1 a	44.1 a	62.3 a	115.8 b
	GF 677	65.1 a	67.2 a	17.9 a	-18.4 b	54.2 a	40.5 a	55.6 a	45.0 a	71.7 a	114.6 a
Flavortop	Adafuel	39.8 ab	47.0 a	28.7 a	27.5 a	25.6 a	27.2 a	35.7 a	39.3 a	35.0 a	44.1 a
	Adarcias	38.9 a	46.2 a	28.6 a	28.7 a	19.4 a	26.0 a	34.9 a	33.6 a	33.2 a	41.9 a
	GF 677	42.0 b	48.3 a	27.0 a	26.5 a	23.4 a	28.4 a	37.0 a	39.7 a	39.0 a	46.7 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 4. Rootstock effect on soluble solids content of fruits.

		SS concentration (ºBrix)		
Cultivar	Rootstock	1999	2000	2001
Catherina	Adafuel	11.3 a	10.3 a	11.1 a
	Adarcias	13.7 c	11.1 a	11.6 b
	GF 677	12.7 b	10.2 a	10.9 a
Flavortop	Adafuel	13.9 a	12.6 a	13.8 a
	Adarcias	14.6 a	13.9 a	14.9 a
	GF 677	14.0 a	13.5 a	14.1 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 5. Rootstock effect on fruit sugars concentration for peach cultivars.

Cultivar	Rootstock	Sacarose (mg/ml)	Glucose (mg/ml)	Fructose (mg/ml)	Sorbitol (mg/ml)
Catherina	Adafuel	73.6 a	9.2 a	10.1 ab	2.0 a
	Adarcias	84.0 b	8.6 a	9.7 a	2.3 a
	GF 677	79.5 ab	8.8 a	10.3 b	1.8 a
Flavortop	Adafuel	8.2 a	16.0 a	17.3 a	4.0 a
	Adarcias	105.2 b	17.7 a	19.3 a	7.2 a
	GF 677	99.0 ab	17.5 a	19.1 a	6.0 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 6. Rootstock effect on fruit acidity for peach cultivars.

		TA (g malic acid/100ml juice)		
Cultivar	Rootstock	1999	2000	2001
Catherina	Adafuel	0.60 a	0.67 ab	0.63 a
	Adarcias	0.75 b	0.70 b	0.69 b
	GF 677	0.67 a	0.56 a	0.66 ab
Flavortop	Adafuel	0.73 a	1.00 a	1.05 a
	Adarcias	0.68 a	0.88 a	1.01 a
	GF 677	0.68 a	0.88 a	1.19 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).

Table 7. Rootstock effect on fruit maturity index for peach cultivars.

		SS/TA (g SS/g malic acid)		
	Rootstock	1999	2000	2001
Catherina	Adafuel	18.8 a	15.5 a	17.5 a
	Adarcias	18.3 a	16.6 a	17.9 a
	GF 677	18.9 a	19.2 a	16.6 a
Flavortop	Adafuel	19.0 a	13.1 a	13.2 ab
	Adarcias	21.5 b	15.9 a	14.9 b
	GF 677	20.6 ab	15.4 a	12.2 a

For each column and cultivar, means followed by the same letter are not significantly different according to Duncan test ($p \leq 0.05$).