Effect of Several Rootstocks on Fruit Quality of 'Sunburst' Sweet Cherry

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Abstract

The influence of CAB 6P, CAB 11E, Masto de Montañana (MM 9), MaxMa 14, MaxMa 97, GM 61/1 (Damil), Colt and Sainte Lucie GF 64 (SL 64) rootstocks on fruit quality of 'Sunburst' sweet cherry is studied. The experiment was performed in the Ebro Valley (Zaragoza, Spain), on a heavy and calcareous soil. To evaluate the effect of rootstocks, parameters such as fruit size, fresh weight, colour, firmness and some chemical fruit properties (acidity, pH and soluble solid content) have been determined. In addition, the most important sugars present in fruit juice (glucose, fructose and sorbitol), were analysed by High Performance Liquid Chromatography (HPLC). Significant differences in sugar concentrations, colour parameters, fruit weight and firmness were found among rootstocks. The highest fruit weight and diameter were induced by *P. cerasus* and 'Colt' rootstocks, especially for the high-yielding years. Preliminary results indicate that rootstocks with high total soluble solids in fruits also showed high values for fruit firmness.

INTRODUCTION

Nowadays, an important requirement for a breeder is not only the productivity, but the quality of fruit obtained from the rootstock-cultivar combination and its adaptation to different soil types.

Influence of rootstocks on fruit size and yield is known (Facteau et al., 1996; Moreno et al., 2001). According to Westwood (1993), the more common effects of rootstocks on fruit quality are differences of firmness, levels of organic acids and sugar content. The three major components of fruit organoleptic quality are flavour, sweetness and acidity, which are highly correlated to several chemical and physical fruit properties (Crisosto et al., 2002).

The present study was carried out over three years with 'Sunburst' sweet cherry growing under calcareous soil conditions. The characteristics of yield, vigour and foliar prognosis were studied in previous work up until 1998 (Moreno et al., 2001). In the present work, the objective was to determine the relative influence of rootstock on fruit quality parameters and some chemical fruit properties. Moreover, we evaluated the sugar composition of fruits.

MATERIAL AND METHODS

Plant Material

The rootstocks under study included three sour cherry (*Prunus cerasus*) selections: CAB 6P, CAB 11E, and Masto de Montañana 9 (MM 9); two selections considered to be of *P. mahaleb* × *P. avium* parentage: MaxMa 14 and MaxMa 97; one selection of *P. dawyckensis*: Grand Manil GM 61/1 (Damil); a *P. mahaleb*: Sainte Lucie GF 64 (SL 64) and a *P. avium* × *P. pseudocerasus*: Colt. They were grafted in situ with 'Sunburst' sweet cherry during the summer of 1989.

Trial Characteristics

The trial was carried out at the Estación Experimental de Aula Dei (Zaragoza, Spain) on calcareous soil, with 35% total calcium carbonate, 8% active lime, pH in water 8.0, and a clay-loam texture. The experiment was designed as described in Moreno et al. (2001).

Yield and Fruit Characteristics

Besides the yield (Kg/tree), mean fruit weight (g), vigour [through the calculation of the trunk cross-sectional area (TCSA), from the measurement of the cultivar trunk girth circumference, 20 cm above the graft], and yield efficiency (Kg cumulative yield/cm^2 of TCSA), fruit quality characteristics were analysed. For 1999, 2000 and 2001, yield, mean fruit weight and size were recorded.

In 2001, yield was much less abundant. During this harvest, 50 fruits of each tree were randomly selected, to estimate fruit quality. Several physical-chemical parameters were considered, such as colour, acidity, pH and firmness. The solid soluble concentration (SS), pH and the acidity were also considered as organoleptic properties.

Concentration of soluble solids (SS) content (ºBrix) from fruit juice from each sample was measured using an Atago PR-101 digital refractometer. Titratable acidity (TA) was determined on a sample of juice from 50 fruits. The juice samples were diluted with distilled water (1:10), and microtitrated with 0.1 mol·l^{-1} NaOH. The fruit colour was measured with a Minolta colorimeter (Minolta, CR-200, Japan). For each sample, values from parameters L*, a* and b* were assigned. Firmness was estimated by a durometer (Shore A, Durofel), a non-destructive method, whose value (from 0 to 1) is relative (Kappel et al., 2000).

Sugar Analysis

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

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., 1998). 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·min^{-1} deionised 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/rootstock. 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.

Analysis of Data

Data were evaluated by analysis of variance with SSPS 10.0 (Norusis, 1999). When the F test was significant, means were separated by Duncan’s test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Cumulative Yield and Yield Efficiency

As previously reported, cumulative yield and yield efficiency of the plantation (Table 1) were generally larger on *P. cerasus* rootstocks (MM 9, CAB 6P and CAB 11E), intermediate on Colt, SL 64, MaxMa 14 and MaxMa 97 rootstocks, and much lower on Damil (Moreno et al., 2001).

Mean Fruit Weight

In the three last years, the fruit weight mean was analysed (Table 1). In 1999, differences between rootstocks were not statistically significant. In 2000, mean fruit weight was greater on MM 9, CAB 6P and CAB 11E. In 2001, SL 64 and Damil induced the lowest fruit weight. The values of fruit weight were higher the last year because of the lowest yield.

Regarding the mean, CAB 11E showed the highest mean fruit weight, followed by CAB 6P, MM 9 and Colt. On the other hand, the lowest values were recorded on SL 64, although this did not differ significantly from MaxMa 14, MaxMa 97, Damil and Colt.

Size

Table 2 shows all the parameters of fruit size that have been considered in the study. For the greater fruit width, MaxMa 14, CAB 11E, CAB 6P and Colt rootstocks showed the highest values. CAB 11E and Colt promoted lesser width in the other direction, followed by CAB 6P and MaxMa 14. The fruit height was higher on Colt, although differences were not significant when compared with CAB 11E and MaxMa 14. The lowest fruit height was shown on Damil and SL 64. On the other hand, fruit height and tree vigour were positively related (r=0.46; p≤0.01) in 2001. Damil presented the lowest value of height/width, and Colt showed the highest value without differing significantly from MaxMa 97 and SL 64.

The high fruit weight observed in 2001 is probably due to the low yields for this year. This has been demonstrated previously by Proebsting (1990). Nevertheless, the influence of rootstocks on fruit size is also demonstrated in this study. Thus, the tendency of *P. cerasus* and Colt to induce greater fruit size was observed, confirming previous results, based on the first productive years of the orchard (Moreno et al., 2001).

Regarding the height/width relation, Damil rootstock showed the lowest value, inducing fruit-flattening, with significant differences with respect to the other rootstocks. On the other hand, Colt showed lengthened fruits. These differences in the fruit form are interesting, since a flattened cherry seems more tempting than a lengthened one.

Skin Colour

MaxMa 14 showed the highest values for the three parameters L*, a* and especially b* (Table 2). On the other hand, CAB 11E induced a clearer red skin colour. Probably, cherries of MaxMa 14 rootstock will be more attractive for the consumer, showing a dark red skin colour (Crisosto et al., 2002)

Soluble Solids Concentration

In 2001, the highest concentration of SS (ºBrix) was observed on Damil, MaxMa 14 and Colt rootstocks (Table 3), the latter did not differ from CAB 6P, CAB 11E and MaxMa 97 rootstocks. In addition, Damil rootstock showed greater SS/TA. However, SL 64 showed the lowest SS concentration. In a previous report (Moreno et al., 2001), Colt also induced a greater concentration of SS than the other rootstocks.

In 2001, all fruits were much sweeter than in previous years, gaining taste quality. The lowest production observed in this year, especially on some rootstocks, seems to allow higher SS quantity, due to lesser competition between fruits. A negative relationship between yield/tree and SS in fruits (r =-0.79; p≤0.01) was shown in 2001 (Fig. 1).

Titratable Acidity and pH

In 2001, TA and pH were not significantly affected by rootstocks (Table 3). However, in a previous report, the *P. cerasus* selections induced the greatest TA in fruit (Moreno et al., 2001). This could be due to the greater yield of these rootstocks.

Firmness

The firmness was greater on Damil, followed by Colt, CAB 6P and MaxMa 14 (Table 3). It was lowest on CAB 11E, followed by MM 9. A positive relationship has been observed between firmness and SS of fruit (r = 0.50; p≤0.01).

Sugar Analysis

In fruit juice, the major soluble sugars were glucose, fructose and sorbitol. The glucose and fructose concentration were about three times and twice the sorbitol concentration respectively. On the other hand, sorbitol concentration was greater compared to other stone fruit species. However, sucrose concentration was very low, as with other minor soluble sugars (data not presented). The values of sugars agree with data obtained in SS.

Rootstock differences in terms of glucose, fructose and sorbitol concentration in fruits have been observed (Table 4). Concentration of glucose and fructose were greater on Damil, although differences were not significantly greater than Colt and MaxMa 14. While concentration of glucose and fructose were lower on SL 64, these did not differ significantly in CAB 6P, CAB 11E, MM 9 and MaxMa 97. Concentration of sorbitol was significantly higher on Damil, probably due to its low yield, while no significant differences were found between all the other rootstocks.

CONCLUSION

In general, the *P. cerasus* selections (CAB 6P, CAB 11E and MM 9) induced greater fruit calibre and fruit weight. In addition, they showed higher yields probably because of a better adaptation to heavy and calcareous soil. Colt rootstock also showed greater calibre and fruit weight and an intermediate level of yield.

The semi-dwarfing habit of MaxMa 14 and high fruit quality may be interesting. Nevertheless, the fruit size of MaxMa 14 is reduced in high-yielding years. Colt appeared to induce higher SS values as previously reported, in spite of the unfavourable growing conditions for this rootstock (chlorosis problems).

Good cherry quality attributes of Damil fruits could be due to a higher maturity index (SS/TA) and limited yield, hence the lower competition between fruits.

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Tables

Table 1. Rootstock effects on trunk cross-sectional area (TCSA) and yield of 'Sunburst' sweet cherry after 11 years in the orchard.

Rootstock	TCSA (cm^2)	Cumulative yield (Kg/tree)	Yield efficiency (Kg/cm^2)	Mean fruit weight (g)			
				1999	2000	2001	Mean
CAB 6P	587 b	317 bcd	0.56 cd	9.2 a	8.2 c	13.0 b	10.1 bc
CAB 11E	562 b	297 bcd	0.53 bcd	10.6 a	8.2 c	13.0 b	10.6 c
MM 9	586 b	345 cd	0.60 d	9.6 a	7.9 c	12.7 b	9.9 bc
MaxMa 14	534 b	236 bc	0.44 b	8.6 a	5.4 ab	13.2 b	9.1 ab
MaxMa 97	495 b	232 bc	0.45 bc	8.9 a	5.6 ab	12.7 b	9.1 ab
Damil	332 a	28 a	0.10 a	10.2 a	4.9 a	11.7 a	9.2 ab
Colt	625 b	252 bc	0.42 b	9.5 a	6.5 b	13.3 b	9.8 abc
SL 64	562 b	213 b	0.47 bc	8.5 a	6.3 b	11.6 a	8.8 a

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

Table 2. Rootstock effects on fruit size and skin colour of 'Sunburst' sweet cherry.

Rootstock	Size (mm)				Colour		
	Width 1	Width 2	Height	Height/Width	L^*	a^*	b^*
CAB 6P	29.6 cd	24.8 c	25.7 bc	0.944 bc	33.5 c	27.6 c	10.2 b
CAB 11E	30.0 d	25.4 d	26.0 cd	0.939 b	31.5 a	21.8 a	8.7 a
MM 9	29.1 b	24.6 bc	25.4 b	0.944 bc	32.3 b	24.5 b	10.0 b
MaxMa 14	30.1 d	24.9 c	25.9 cd	0.946 bc	33.7 c	27.7 c	11.7 c
MaxMa 97	29.2 bc	24.2 a	25.5 b	0.951 cd	32.8 bc	27.0 c	9.9 b
Damil	28.8 b	24.3 ab	24.9 a	0.932 a	32.8 bc	26.2 bc	9.6 b
Colt	29.6 cd	25.2 d	26.1 d	0.954 d	33.1 bc	26.3 bc	10.8 b
SL 64	28.3 a	24.4 ab	24.9 a	0.949 cd	32.6 b	26.2 bc	9.8 b

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

Table 3. Rootstock effects on firmness, pH, SS, acidity and SS/acidity of 'Sunburst' sweet cherry.

Rootstock	Firmness	pH	SS (ºBrix)	TA (g malic acid/l juice)	SSC/TA
CAB 6P	0.51 e	3.8 a	19.7 c	9.5 a	2.05 a
CAB 11E	0.34 a	3.7 a	19.7 c	9.0 a	2.20 a
MM 9	0.41 b	3.6 a	19.1 b	9.0 a	2.16 a
MaxMa 14	0.48 d	3.7 a	20.5 d	9.1 a	2.17 a
MaxMa 97	0.44 c	3.4 a	19.9 c	8.7 a	2.32 a
Damil	0.55 f	3.7 a	22.4 e	8.5 a	2.70 b
Colt	0.51 e	3.7 a	20.3 cd	9.2 a	2.23 a
SL 64	0.44 c	3.6 a	18.3 a	8.4 a	2.18 a

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

Table 4. Rootstock effects on sugar content of 'Sunburst' sweet cherry.

	Sugar concentration (mg/ml juice)		
Rootstock	Glucose	Fructose	Sorbitol
CAB 6P	80.0 ab	64.8 ab	27.4 a
CAB 11E	78.8 ab	64.2 ab	26.5 a
MM 9	78.3 ab	64.1 ab	26.2 a
MaxMa 14	82.3 abc	67.3 abc	29.9 a
MaxMa 97	80.2 ab	65.5 ab	28.5 a
Damil	88.0 c	73.0 c	35.6 b
Colt	84.3 bc	69.7 bc	30.3 a
SL 64	75.9 a	61.0 a	26.1 a

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

Figures

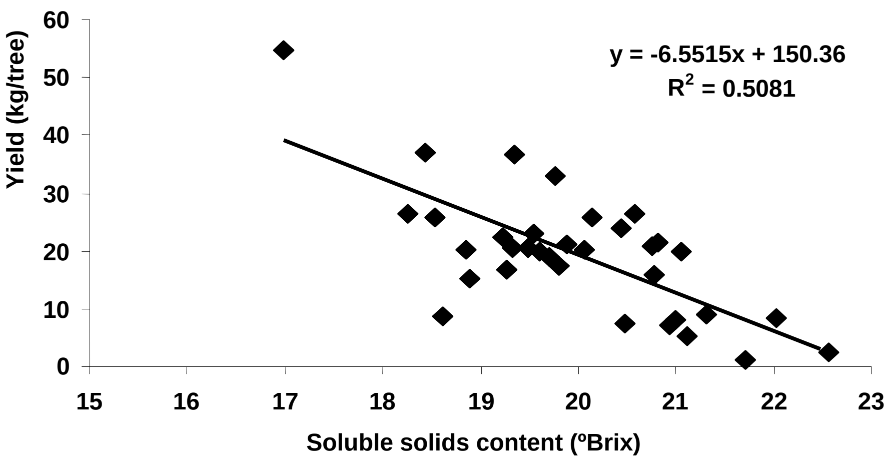

Fig. 1. Yield and soluble solids content of fruits relationship in 2001.