Acta Horticulturae 1161: 315-320 (2017)

Effect of Eight Different Rootstocks on Agronomic and Fruit Quality Parameters of Two Sweet Cherry Cultivars in Mediterranean Conditions

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Keywords: *Prunus avium*, vigour, yield, productivity, fruit size, SSC, firmness

Abstract

The influence of Adara, CAB 6P, Gisela 5, MaxMa 14, Saint Lucie GF 64 (SL 64), Saint Lucie GF 405 (SL 405), Tabel-Edabriz and VSL 2 rootstocks onto fruit weight, soluble solids content (SSC), pH, firmness, titratable acidity (TA) and ripening index of 'Van' and 'Stark Hardy Giant' sweet cherry cultivars was studied during three consecutive years, between the eleventh and thirteenth year after budding. Trunk cross sectional area (TCSA), annual production and yield efficiency were also determined. The experiment was performed in the Ebro Valley (Zaragoza, Spain), on a heavy and calcareous soil. Significant differences for most agronomic and fruit quality parameters were observed among rootstocks. By year thirteenth, 'Van' trees on Adara and 'SHG' on MaxMa 14 showed the highest vigour (TCSA) whereas the lowest values were shown by Gisela 5 for both cultivars. The cumulative yield was the highest on Adara rootstock for 'Van' cultivar, although no significant differences were found when compared with CAB 6P. Similarly, the cumulative yield for 'SHG' was also higher for these rootstocks and MaxMa 14. The highest yield efficiency was recorded on Gisela 5 and CAP 6P for both cultivars, although no significant differences were found between them and Adara in the case of 'Van'. Regarding fruit quality, cherries of 'SHG' trees budded on Adara and Gisela 5 showed higher firmness. Despite the higher firmness of fruits on Gisela 5 and highest yield efficiency, the smaller size of fruits resulted in a non-interesting rootstock in terms of fruit quality for the growing conditions. This study demonstrates that the scion-rootstock combination greatly influences some important sweet cherry attributes such as vigour, yield, fruit size, SSC, and firmness.

INTRODUCTION

It has been reported that different rootstocks influence the performance of the budded cherry cultivars (Facteau et al., 1996; Moreno et al., 1996). The most common effects of rootstocks on fruit quality are differences of firmness, levels of organic acids and sugar content (Moreno et al., 2001; Cantín et al., 2010). A better understanding of the relationships between some cherry fruit quality attributes and rootstock influence is needed to achieve favourable scion/rootstock combinations for specific growing areas.

Sweet cherries have expanded rapidly in Spain over the past decade, being the fifth largest producer of sweet cherries in the world with 101,700 tonnes in 2011 (FAOSTAT, 2013). In turn, the Ebro Valley is the first producer region in Spain, and consequently one of the most important productive areas of Europe with around 32,000 tons per year averaged for the last five year period.

The present study was carried out over three years (eleventh to thirteenth year after budding) with 'Van' and 'Stark Hardy Giant' sweet cherry cultivars, budded on seven different rootstocks, and grown on heavy and calcareous soil conditions in the Ebro Valley (Spain). The aim of this study was to assess the influence of these rootstocks on vegetative growth, yield and fruit quality of these two sweet cherry cultivars when grow under typical Mediterranean conditions.

MATERIALS AND METHODS

Plant material

Eight cherry rootstocks were compared in one trial established in the winter of 1997-1998. They were budded *in situ* with 'Stark Hardy Giant' ('SHG') and 'Van' mid- to late-maturing sweet cherry cultivars (*Prunus avium* L. – *P. avium*) during the summer of 1998.

Rootstocks under evaluation included two sour cherry (*P. cerasus*) selections: CAB 6P and Tabel-Edabriz (Tabel); two selections of *P. mahaleb*: Saint Lucie GF 64 (SL 64) and Saint Lucie GF 405 (SL 405); a *P. cerasifera* rootstock: Adara; one semi-dwarfing selection considered to be of *P. avium* x *P. mahaleb* parentage: MaxMa 14; a selection from the cross *P. fruticosa* x *P. serrulata*: VSL-2; and a dwarfing *P. cerasus* x *P. canescens*: Gisela 5. Due to bud-take and mortality problems of 'Van' budded on Tabel and SL 405 respectively, these rootstock-cultivar combinations were not included in the study.

The trial was carried out at the Experimental Station of Aula Dei (Zaragoza, Spain) on a calcareous soil, with 27% total calcium carbonate, 8% active lime, water pH 8.3, and a clay-loam texture. Trees were planted at 5 x 4 m, and were minimal pruned throughout the experiment, excepting the Spanish bush developed the first years. This training system controlled tree height by pruning in the summer and fall. The orchard was managed following the usual local procedures. The plot was level-basin irrigated every 12 days during the summer. 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 growth, yield and fruit quality attributes

Trunk girths were measured during the dormant season at 20 cm above the graft union, and the trunk cross-sectional area (TCSA) was calculated. Cumulative yield per tree and yield efficiency (cumulative yield in kg per final TCSA) of each scion-stock combination were computed from the harvest data.

Over the three years of study, the cherries were hand-picked at commercial maturity over a period of 5-10 days, depending on the year, to assess optimum maturity for a given scion-rootstock combination. Fruits were considered ripe when they exhibited the red ground colour representative for each cultivar. Fruits were harvested by a single person to keep consistency of maturity grade. At each harvest, 50 fruits at commercial ripening stage were sampled from each single-tree repetition and they were immediately used to determine fruit weight (FW, g), soluble solids content (SSC, ºBrix), titratable acidity (TA, g malic acid per 100 g FW), pH, flesh firmness (FF) and colour.

Fruit juice SSC from each sample was measured using an Atago PR-101 digital refractometer and expressed in ºBrix. Titratable acidity (TA) was determined in a sample of juice from 50 fruits. The juice samples were diluted with distilled water (1:10), and microtitrated with 0.1 N NaOH. Firmness was estimated by a durometer (Shore A, Durofel), a non-destructive method, whose value (from 0 to 100 durofel graduation) is a relative value of firmness (Kappel et al., 2000). The ripening index (RI) was calculated based on the SSC/TA ratio. Skin colour was measured in 50 fruits with a tristimulus colourimeter (Minolta CR-200 Chroma Meter, Minolta, Japan) having an 8-mm-diameter viewing area (Font i Forcada et al., 2012). Values of lightness (L*), redness and greenness (a* and –a*) and yellowness and blueness (b* and –b*) on the hue circle (Voss, 1992) were measured to describe a three-dimensional colour space. The values presented for each measurement date are the means of triplicate measures on equidistant points of each fruit.

Data analysis

Data were evaluated by analysis of variance with SPSS 19.0 (SPSS, Inc, Chicago, USA). When the F test was significant, means were separated by Duncan's Multiple Range Test ($P \leq 0.05$). In addition, the analyses of bilateral Pearson correlation were carried out to conclude relationships between parameters.

RESULTS AND DISCUSSION

Tree growth: Tree size, as assessed by TCSA, was significantly affected by rootstock starting from the fourth year after grafting (Cantín et al., 2010). In the thirteenth year after budding (Table 1), 'Van' trees budded on Adara showed the highest TCSA value, although differences were not significant with MaxMa 14. For 'SHG', the highest vigour was found on MaxMa 14, followed by SL 64, Adara and CAB 6P. The high vigour shown by these rootstocks may be recommendable when planting on poor soils or under replanting conditions (Moreno et al., 1996). The lowest TCSA was shown by Gisela 5 for both cultivars, and followed by VSL-2 mainly in 'SHG' trees. In the Mediterranean area, the poor growth induced by Gisela 5 has been previously reported (De Salvador et al., 2001; Cantín et al., 2010).

Yield, cumulative yield and yield efficiency: Throughout the last three years of study, Adara induced, in general, the highest yield for both cultivars (data not shown), while dwarfing Gisela 5 induced the lowest. The high vigour and yield shown by Adara has already been reported (Moreno et al., 1996; Jiménez et al., 2007), and it could be explained by its best nutrient status in heavy and calcareous soils.

By year thirteenth after budding, the cumulative yield of 'Van' trees was greater on Adara rootstock (Table 1), although no significant differences were shown when compared with CAB 6P. For 'SHG', cumulative yield was higher on CAB 6P, MaxMa 14 and Adara, although it did not differ from SL 64. As expected, a highly significant ($P \leq 0.001$) correlation was observed for both cultivars between tree vigour (TCSA) and cumulative yield ($r = 0.86$ and $r = 0.90$ for 'Van' and 'SHG', respectively).

The highest yield efficiency recorded on Gisela 5 for both cultivars could be associated with its lower vigour. In the case of CAB 6P and Adara, their highest yield efficiency could be associated with their higher yield and cumulative yield. In contrast, the lowest yield efficiency observed, in general, for the *P. mahaleb* selections, probably is due to their susceptibility to root asphyxia in heavy soils with level-basin irrigated system where waterlogging occur (Moreno et al., 1996; Moreno et al., 2001).

Fruit quality: Rootstocks significantly influenced FW, SSC, RI, FF (Table 2) and several fruit colour parameters (Table 3). However, no consistent differences were found among rootstocks for TA along the study for any of the cultivars. For 'Van' cultivar, CAB 6P, MaxMa 14 and SL 64 induced higher fruit weight, while Gisela 5 showed the lowest. In a similar way for 'SHG', the highest fruit weight was induced by CAB 6P, MaxMa 14 and both *P. mahaleb* rootstocks. The tendency of Gisela 5 to induce lower fruit size has been also reported in these growing conditions (Cantín et al., 2010). For 'Van' cultivar, SL 64 induced the highest value of SSC, although no significant differences were found with Adara and VSL-2. Again, for ‘SHG’, SL 64 and VSL-2 showed higher SSC, although they did not differ significantly from SL 405 and MaxMa 14. Regarding fruit firmness, cherries of ‘SHG’ trees budded on Adara and Gisela 5 showed higher firmness. For ‘Van’ cultivar, MaxMa 14 showed significant higher L* parameter (luminosity) than the other rootstocks with the exception of VSL-2. With regard to a* parameter, the highest values for ‘Van’ cultivar were recorded on MaxMa 14 and VSL-2 and the lowest on SL 64, without significant differences among the other rootstocks. In the case of the b* parameter, the highest values for ‘Van’ cultivar were found on MaxMa 14 without significant differences from VSL-2 and CAB 6P. These data mean that trees budded on MaxMa 14 and VSL-2 would have redder and darker cherries than fruits from other rootstocks.

CONCLUSION

The scion-rootstock combination greatly influences some important sweet cherry attributes such as vigour, yield, fruit size and firmness, colour and SSC. This study confirmed the best agronomic performance in heavy and calcareous soils and the best fruit quality traits induced by some of the evaluated rootstocks, especially for Adara and CAP 6P. The high fruit quality (fruit weight, SSC and skin colour) on MaxMa 14 and/or SL 64 may also be interesting when these rootstocks are grown in well-drained calcareous soils.

ACKNOWLEDGEMENTS

This study was funded by the Spanish MICINN and MINECO grants AGL2005-05533, AGL2008-00283, AGL2011-24576, and HH2008-0012, co-funded by FEDER and the Regional Government of Aragón (A44).

Literature Cited

Cantín, C.M., Pinochet, J., Gogorcena, Y. and Moreno, M.A. 2010. Fruit quality and yield of ‘Van’ and ‘Stark Hardy Giant’ sweet cherry cultivars as influenced by grafting on different rootstocks. Sci Hortic 123:329-335.

De Salvador, F.R., Di Tommaso, G., Piccioni, C. and Bonofiglio, P. 2001. Performance of new and standard cherry rootstocks in different soils and climatic conditions. Acta Hortic. 667:191-199.

FAOSTAT (2013) http://faostat.fao.org/

Facteau, T.J., Chestnut, N.E. and Rowe, K.E. 1996. Tree, fruit size and yield of 'Bing' sweet cherry as influenced by rootstock, replant area, and training system. Sci. Hortic. 67(1-2):13-26.

Font i Forcada, C., Gogorcena Y. and Moreno, M.A. 2012. Agronomical and fruit quality traits of two peach cultivars on peach-almond hybrid rootstocks growing on Mediterranean conditions. Sci. Hortic. 140:157-163.

Jiménez, S., Pinochet, J., Gogorcena, Y., Betrán, J.A. and Moreno, M.A. 2007. Influence of different vigour cherry rootstocks on leaves and shoots mineral composition. Sci. Hortic. 112(1):73-79.

Kappel, F., Lane, W.D., MacDonald, R.A. and Schmid, H. 2000. 'Skeena' sweet cherry. HortScience 35(2):306-307.

Moreno, M.A., Montañés, L., Tabuenca, M.C. and Cambra, R. 1996. The performance of Adara as a cherry rootstock. Sci. Hortic. 65(1):85-91.

Moreno, M.A., Adrada, R., Aparicio, J. and Betrán, J.A. 2001. Performance of ‘Sunburst’ sweet cherry grafted on different rootstocks. J. Hortic. Sci. Biotechnol. 76:167-173.

Voss, D.H. 1992. Relating colorimeter measurement of plant color to the Royal Horticultural Society color chart. HortScience 27(12):1256-1260.

Tables

Table 1. Effect of rootstock on yield, trunk cross-sectional area (TCSA), cumulative yield and yield efficiency of 'Van' and 'Stark Hardy Giant' cherry cultivars, at the thirteenth year after grafting (2011).

Cultivar	Rootstock	TCSA (cm^2)	Cumulative yield (kg $tree^{-1}$)	Yield efficiency (kg cm^{-2})
'Van'	Adara	563.2 d	514.6 d	0.92 b
	CAB 6P	345.8 bc	414.7 cd	1.22 c
	Gisela 5	61.8 a	75.1 a	1.21 c
	MaxMa 14	475.8 cd	340.7 bc	0.75 ab
	SL 64	328.0 bc	251.3 b	0.76 ab
	VSL2	222.0 b	127.5 a	0.64 a
'SHG'	Adara	346.6 d	287.7 cd	0.83 bc
	CAB 6P	307.9 d	316.0 d	1.03 c
	Gisela 5	40.5 a	40.5 a	0.99 c
	MaxMa 14	440.5 e	312.9 d	0.72 ab
	SL 64	354.1 d	217.8 bc	0.61 a
	SL 405	225.5 c	173.4 b	0.78 ab
	VSL2	124.1 b	76.4 a	0.61 a

For each cultivar, means followed by the same letter in each column are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Table 2. Effect of rootstock on fruit weight (FW), soluble solids content (SSC), titratable acidity (TA), ripening index (RI) and flesh firmness (FF) of 'Van' and 'Stark Hardy Giant' sweet cherry cultivars. Data represent the average value of three consecutive years.

Cultivar	Rootstock	FW	SSC	TA	RI	FF
'Van'	Adara	5.8 b	18.6 ab	0.82 a	24.4 ab	53.7 a
	CAB 6P	6.7 c	18.1 a	0.85 a	22.3 a	53.3 a
	Gisela 5	4.9 a	18.4 a	0.77 a	26.5 b	53.6 a
	MaxMa 14	6.7 c	17.8 a	0.85 a	21.8 a	53.4 a
	SL 64	6.8 c	19.5 b	0.86 a	23.5 a	53.8 a
	VSL2	6.5 bc	18.7 ab	0.87 a	22.0 a	53.0 a
'SHG'	Adara	5.7 ab	17.0 a	0.76 a	24.1 a	57.6 b
	CAB 6P	6.6 b	17.8 a	0.78 a	25.5 a	53.6 a
	Gisela 5	4.9 a	17.8 a	0.79 a	26.5 a	57.1 b
	MaxMa 14	6.2 b	17.3 a	0.75 a	25.7 a	54.3 a
	SL 64	6.6 b	18.4 b	0.83 a	25.3 a	54.5 a
	SL 405	6.4 b	17.4 a	0.77 a	25.4 a	53.9 a
	VSL2	6.6 b	18.2 b	0.83 a	24.8 a	54.2 a

For each cultivar, means followed by the same letter in each column are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Table 3. Effect of rootstock on chromatic parameters (L*= lightness; a*= redness and greenness; and b*= yellowness and blueness; C*= chroma; h= lightness's angle) of 'Van' and 'Stark Hardy Giant' sweet cherry cultivars. Data represent the average value of three consecutive years.

Cultivar	Rootstock	L*	a*	b*	C*	h*
'Van'	Adara	29.1 a	19.6 ab	3.7 a	13.3 a	17.2 a
	CAB 6P	29.3 ab	20.4 ab	4.1 abc	14.6 a	17.3 a
	Gisela 5	29.0 a	19.9 ab	3.9 ab	14.7 a	16.4 a
	MaxMa 14	29.8 c	21.9 b	4.7 c	15.6 a	18.7 a
	SL 64	29.0 a	18.2 a	3.4 a	13.4 a	15.4 a
	VSL2	29.7 bc	21.7 b	4.6 bc	15.0 a	18.9 a
'SHG'	Adara	29.7 a	22.4 ab	8.5 a	14.7 a	16.8 a
	CAB 6P	29.3 a	19.8 ab	5.6 a	13.5 a	15.9 a
	Gisela 5	29.8 a	22.9 b	8.9 a	15.1 a	17.3 a
	MaxMa 14	29.1 a	19.8 ab	7.0 a	13.1 a	15.4 a
	SL 64	29.1 a	19.4 a	4.0 a	13.7 a	17.2 a
	SL 405	29.2 a	19.5 a	5.6 a	13.3 a	15.8 a
	VSL2	29.1 a	19.3 a	7.9 a	12.3 a	14.2 a

For each cultivar, means followed by the same letter in each column are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.