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Agromorphological characterization of traditional Spanish sweet cherry (*Prunus avium* L.), sour cherry (*Prunus cerasus* L.) and duke cherry (*Prunus* × *gondouinii* Rehd.) cultivars

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Abstract

Thirty-one traditional cultivars [26 sweet cherry (*Prunus avium* L.), four duke cherry (*Prunus* × *gondouinii* Rehd.), and one sour cherry (*Prunus cerasus* L.)] from Sierra de Francia and Arribes del Duero in Central-Western Spain were surveyed and characterized agromorphologically. A total of 37 descriptors, mainly defined by the International Plant Genetic Resources Institute and the International Union for the Protection of New Varieties of Plants were used to describe flowers, leaves, fruits and the tree itself over a 3 consecutive years. This made possible the unequivocal identification of 25 cultivars. A dendrogram gave a clear separation between the sour, duke and sweet cherry cultivars and showed existing synonymies and homonymies. This work is an important step in the conservation of genetic cherry resources in the province of Salamanca (Spain), which show distinctive and interesting agronomical characters such as low susceptibility to fruit cracking, high levels of soluble solids, early fruit maturity and great rusticity.

Additional key words: cherry descriptors, conservation, endangered cultivars, fruit parameters, genetic resources, homonymies, synonymies.

Resumen

Caracterización agromorfológica de cultivares tradicionales españoles de *Prunus avium* L., *Prunus cerasus* L. y *Prunus* × *gondouinii* Rehd.

Veintiséis cultivares de cerezo (*Prunus avium* L.), un cultivar de guindo (*Prunus cerasus* L.) y cuatro cultivares del híbrido de ambos (*Prunus* × *gondouinii* Rehd.), originarios de las zonas de Sierra de Francia y de Arribes del Duero, en el centro-oeste español, han sido prospectados y caracterizados desde el punto de vista agromorfológico. Un total de 37 descriptores, la mayoría definidos por el *International Plant Genetic Resources Institute* y por la *International Union for the Protection of New Varieties of Plants* fueron usados para describir flores, hojas, frutos y el árbol durante un periodo consecutivo de tres años, permitiendo la inequívoca identificación de 25 cultivares. El dendrograma de relación entre cultivares elaborado permite diferenciar claramente los cultivares de cerezo, guindo e híbrido estudiados y muestra la existencia de sinonimias y homonimias. El trabajo realizado constituye un paso importante para la conservación de estos recursos genéticos presentes en la provincia de Salamanca (España) que muestran caracteres agronómicos interesantes y distintivos tales como baja susceptibilidad al rajado, altos niveles de sólidos solubles, maduración temprana y gran rusticidad.

Palabras clave adicionales: conservación, cultivares en peligro, descriptores de cerezo, homonimias, parámetros de fruto, recursos genéticos, sinonimias.

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Introduction[1]

The sweet cherry (*Prunus avium* L., Rosaceae, 2n = 2x = 16) is a deciduous, allogamous species that is generally self-incompatible. It is cultivated for its edible fruit and wood. The sour cherry (*P. cerasus* L., Rosaceae, 2n = 4x = 32) is cultivated for its sharp tasting, succulent fruit. Sour cherry fruit is mostly used for industrial preserves (jam and other uses). Sour cherry is also used as a sweet cherry rootstock. Both species originated around the Black and Caspian Seas and were cultivated in temperate and cool regions. Both sweet and sour cherry spread slowly from their origin to other regions due to human and animal migrations (Moreno and Manzano, 2002). By 2005, world production of sweet cherry and sour cherry was 1.86 and 1.23 million Mg, respectively (FAOSTAT, 2005). Turkey, the United States, Iran, Germany, the Russian Federation and Italy are the most important sweet cherry producing countries (approximately 57% of world sweet cherry production). For sour cherry the Russian Federation, Ukraine, Turkey, Poland and Serbia & Montenegro are the most important producing countries (roughly 65% of world sour cherry production). In 2005, Spain produced 89,300 Mg of sweet cherries and 1,400 Mg of sour cherries (FAOSTAT, 2005). The main sweet and sour cherry producing areas in Spain are the Jerte river valley, Aragón-Catalonia, high altitude areas of Jaén-Granada and the mountains of the Valencian Community (Moreno and Manzano, 2002).

The area of this study is part of a large growing area known as the «Jerte and neighbouring regions» in west-central Spain. Sweet cherry has been cultivated in this area for many years; this crop has been documented since the 14th century (Flores del Manzano, 1985). The region has approximately 7,500 ha dedicated to sweet cherry production and produces 28,000 Mg of fruit per year. Sour cherry occupies marginal low-productivity zones of limited agricultural interest. In the area, due to the steepness of the hill slopes sweet cherry is mainly cultivated on terraces at different altitudes. Farms are usually family-run or cooperatives. An unknown number of local sweet cherry cultivars are still present in the zone. However, these cultivars are currently in decline and have been since early in the 20th century due to the introduction of new cultivars from foreign sweet cherry breeding programs (e.g. Canada, the United States and France); these cherries are better-suited to market requirements and have better agronomic characteristics. However, the conservation and characterization of these local cultivars is important to avoid the loss of genetic variability and as a potential source of genetic variation for future sweet cherry breeding programs. These cultivars show distinctive agronomic characters such as low susceptibility to fruit cracking, high levels of soluble solids, early fruit maturity and great rusticity.

A first step in avoiding the disappearance of these traditional cultivars is to survey their various cultivation zones. The first work in characterizing sweet cherry was by Christensen (1969, 1970, 1974, 1985). This author evaluated morphologically different sweet cherry cultivars and proposed a code for their identification. Other authors who have studied sweet and sour cherry morphology are Fogle (1961), and Hillig and Iezzoni (1988). As a result of their efforts, cultivar descriptors were developed by IPGRI (1985) and UPOV (1976). Based on some of these descriptors, Moreno *et al.* (2001) identified and characterized 34 cultivars of sweet cherry trees cultivated in the Jerte valley and established a germplasm bank with them in Barrado (Cáceres, Spain). Until now, this has been the only systematic survey carried out in the nearby cherry growing areas.

The objective of this study was to survey, identify and characterize traditional sweet and sour cherry cultivars existing in the province of Salamanca (Spain) for their later introduction into a germplasm bank.

Material and Methods

Cultivars survey

A survey was made of the two main sweet and sour cherry producing areas of Salamanca Province: Arribes del Duero and Sierra de Francia. During this phase of the research, 60 interviews were conducted with farmers and cooperatives that operate in both areas. The process consisted of locating, by GPS, and labelling cherry tree cultivars with specific names that farmers indicated were old or local. For each marked tree, an information file was recorded that included data on the place of collection. During this search, 160 trees were labelled. In the first group were 26 sweet cherry and five sour cherry cultivars. Table 1 shows all the studied cultivars

[1] Abbreviations used: D_g (geometric mean diameter), GPS (global positioning system), IPGRI (International Plant Genetic Resources Institute), L (length), T (thickness), UPOV (International Union for the Protection of New Varieties of Plants), W (width), Ø (sphericity).

Table 1. List of 31 sweet and sour cherry cutivars examined in this study with their origin

Cultivar	*A priori* species assignation	*A posteriori* species assignation	Origin
'Ambrunés Especial'	*Prunus avium*	*Prunus avium*	Italy
'Aragonesa'	*Prunus avium*	*Prunus avium*	Spain
'Blanca de Provenza'	*Prunus avium*	*Prunus avium*	Provenza (France)
'Boba'	*Prunus avium*	*Prunus avium*	Germany
'Burlat'	*Prunus avium*	*Prunus avium*	Rhone valley (France)
'California'	*Prunus avium*	*Prunus avium*	Summerland (Canada)
'Corazón Serrano'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Costalera'	*Prunus avium*	*Prunus avium*	Valle del Jerte (Spain)
'De Valero'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Del País 1'	*Prunus avium*	*Prunus avium*	Arribes del Duero (Spain)
'Del País 2'	*Prunus avium*	*Prunus avium*	Arribes del Duero (Spain)
'Del País T'	*Prunus avium*	*Prunus avium*	Arribes del Duero (Spain)
'Del Valle'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Garrafal Napoleón'	*Prunus avium*	*Prunus avium*	Germany
'Guindo del País 1'	*Prunus cerasus*	*Prunus cerasus*	Salamanca (Spain)
'Guindo del País 2'	*Prunus cerasus*	*Prunus* × *gondouinii*	Salamanca (Spain)
'Guindo Garrafal Negro'	*Prunus cerasus*	*Prunus* × *gondouinii*	Sierra de Francia (Spain)
'Guindo Tomatillo 1'	*Prunus cerasus*	*Prunus* × *gondouinii*	Salamanca (Spain)
'Guindo Tomatillo 2'	*Prunus cerasus*	*Prunus* × *gondouinii*	Salamanca (Spain)
'Jarandilla'	*Prunus avium*	*Prunus avium*	Cáceres (Spain)
'Lamper'	*Prunus avium*	*Prunus avium*	USA
'Mollar'	*Prunus avium*	*Prunus avium*	Cáceres (Spain)
'Monzón'	*Prunus avium*	*Prunus avium*	Germany
'Moracha'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Pedro Merino'	*Prunus avium*	*Prunus avium*	Valle del Jerte (Spain)
'Pical'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Pico Negro'	*Prunus avium*	*Prunus avium*	Valle del Jerte (Spain)
'Picota'	*Prunus avium*	*Prunus avium*	Valle del Jerte (Spain)
'Rabo Largo Negra'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)
'Ramón Oliva'	*Prunus avium*	*Prunus avium*	Spain
'Reondal'	*Prunus avium*	*Prunus avium*	Sierra de Francia (Spain)

and their origin. At full fruit maturity five trees of each cultivar were chosen.

Descriptors analysed

Agromorphological characterization of all marked trees in the search was carried out using as a base 18 descriptors established by IPGRI and UPOV and a further 19 descriptors that were considered relevant for identification. For determination of some of the descriptors, samples of flowers, fruits and leaves were taken during 2003, 2004 and 2005 using UPOV guidelines (1976). Flowers were collected at full bloom. From each of the five trees studied per cultivar and year, 10 flowers were taken, and the following parameters measured using a digital calliper: open flower diameter (cm), petal length (cm), petal width (cm), and pistil length (cm). The number of stamens in each flower was also counted. Cherry fruit was collected at maturity. Maturity was determined on the basis of the colour characteristics of each cultivar, taking into account information provided by growers and from personal experience and observation. A sample total of 106 cherry fruits were taken from each of the five trees studied per cultivar and year, of these 100 were used to determine the 100 fruit weight and resistance to cracking after immersion in distilled water at 20°C for 6 h (Christensen, 1972). The remaining six cherries were used to study a series of quantitative and qualitative descriptors. The quantitative descriptors recorded were: stalk length (cm), fruit volume (cm^3), endocarp volume (cm^3), geometric mean diameter (mm), surface area of the fruit (cm^2), sphericity (%), the relative seed size with respect to the fruit, total soluble solids (°Brix), and titratable acidity (g of malic acid/100 g fresh weight).

To determine average cherry size, six cherries per tree and year were picked at random and their three linear dimensions, namely length (L), width (W) and thickness (T), were measured using a digital calliper with a sensitivity of 0.01 mm. The callipers were also used to measure fruit peduncle length. Cherry and endocarp volume were calculated using the formula $^4/_3\pi r^3$, where $r = [L + W + T]/6$. Geometric mean diameter (D_g) and sphericity (Ø) were calculated using the following equations $D_g = (LWT)^{0.333}$ and $Ø = [(LWT)^{0.333}]/L$ (Mohsenin, 1978; Aydin, 2003; Olajide and Igbeka, 2003; Vursavuş and Özgüven, 2004). Following Mohsenin (1978) and Baryeh (2001), fruit surface area (S) can be expressed as $S = \pi D_g^2$. Fruit mass was measured on an electronic balance with a sensitivity of ± 0.001 g. Relative cherry seed size compared to fruit was calculated using the ratio: endocarp volume/fruit volume. Total soluble solids in each fruit were determined with a digital refractometer (Atago PR-101, Atago Co. Ltd., Japan) at 20°C and titratable acidity was determined in each fruit by potentiometric titration with 0.1 N NaOH up to pH 8.1, using 1 mL of diluted juice in 25 mL distilled H_2O.

Qualitative descriptors observed were: skin colour, pulp and juice; fruit shape, endocarp and pistilar point; external discolouration; and the presence or absence of leaves at the base of the fruit peduncle. Leaves were collected at adult stage, at approximately the end of July. From each of the five trees studied per cultivar, seven leaves were sampled per year, and the following parameters measured using a digital calliper with a sensitivity of ± 0.01 mm: leaf blade length and width (cm), petiole length (cm) and, using a protractor, the basal and apical angles of the blade (°) were measured. Anthocyanin pigmentation of the nectaries was also observed. Two ratios were calculated: the length/width of the leaf blade; and petiole length/leaf blade length.

With regard to whole trees, only the vegetative habit of the different cultivars was evaluated.

Means and standard deviations were calculated, for each of the parameters studied, over the 3 years for the 26 sweet cherry and five sour cherry cultivars. The unit of measurement of each of the parameters studied was done from an individual value of each of five trees sampled per variety. Finally, a dendrogram of genetic similarities among cultivars was compiled using the Furthest Neighbour Method and an analysis of variance (ANOVA) was carried out for the different cherry species and for local and improved sweet cherry cultivars. Differences between means were investigated using Duncan's multiple range test. All statistical analyses used Statgraphics Plus 5.0.

Results and Discussion

Flowers

Flower parameters are summarized in Table 2. Open flower diameter ranged from 2.95 to 3.81 cm in sweet cherries ('Garrafal Napoleón', 'Burlat' and 'Boba' were the cultivars with the largest flowers), and from 2.55 to 3.4 cm in sour cherries. Generally, sour cherries had smaller flowers than the sweet cherries. In all cases petal length was highly correlated (r = 0.96) with flower size. Petal width varied from 0.96 to 1.54 cm. Lowest values were observed for 'Del País 2' and 'Pico Negro' sweet cherries. Stamen number varied from 25 to 38 in the sweet cherries and from 24 to 29 in sour cherries. Pistil length ranged from 1.29 to 1.73 cm in sweet cherries and from 1.09 to 1.38 in sour cherries. 'Guindo del País 1' was the cultivar with the smallest pistil. Both the sweet and sour cherry cultivars showed minimal differences in flower parameters over the three years.

It was observed in sweet cherry cultivars that genetically improved introduced cultivars generally had larger flowers than local cultivars (Table 3). Cultivar 'Monzón', selected in Germany, had an average open-corolla diameter of 3.75 cm and an average petal length and width of 1.62 and 1.34 cm, respectively. Its mean pistil length was also quite high, at 1.52 cm. On the other hand, the local cv. 'Del País 2' had considerably smaller flowers, with a mean open-corolla diameter of 2.95 cm and a mean petal length and width of 1.33 and 0.96 cm, respectively. Its pistil was also shorter (1.37 cm). The flowers of both sweet cherry cultivars are shown in Figure 1. In sour cherry, flowers of the cvs. 'Guindo Tomatillo 1', 'Guindo Tomatillo 2', 'Guindo del País 2' and 'Guindo Garrafal Negro' were bigger than those of the cv. 'Guindo del País 1'. Cordeiro (2004) observed that the sour cherry cultivar 'Garrafal Negra' had larger flowers than the other sour cherry cultivars studied.

Leaves

Leaf parameters are shown in Table 4. Highest values for the basal leaf angle were in the 'Aragonesa' and 'Pedro Merino' sweet cherries, and the lowest in 'Costalera' and 'Mollar'. Apical leaf angle ranged from

Table 2. Flower parameters in sweet (sw) (*P. avium*) and sour (so) (*P. cerasus*) cherry cultivars, including (SD)

Cultivar	Open flower diameter (cm)	Petal length (cm)	Petal width (cm)	Pistil lenght (cm)	Number of stamens
'Ambrunés Especial' (sw)	3.56 (0.18)	1.50 (0.11)	1.10 (0.18)	1.40 (0.05)	30.71 (3.35)
'Aragonesa' (sw)	3.74 (0.25)	1.57 (0.14)	1.24 (0.15)	1.46 (0.10)	34.85 (3.42)
'Blanca de Provenza' (sw)	3.26 (0.37)	1.38 (0.15)	1.13 (0.19)	1.37 (0.10)	38.62 (2.92)
'Boba' (sw)	3.78 (0.22)	1.65 (0.12)	1.33 (0.21)	1.62 (0.09)	33.87 (2.98)
'Burlat' (sw)	3.78 (0.45)	1.67 (0.19)	1.31 (0.15)	1.56 (0.05)	33.86 (5.42)
'California' (sw)	3.48 (0.36)	1.50 (0.13)	1.30 (0.26)	1.43 (0.05)	33.08 (3.63)
'Corazón Serrano' (sw)	3.68 (0.37)	1.52 (0.19)	1.26 (0.24)	1.54 (0.08)	33.05 (3.26)
'Costalera' (sw)	3.46 (0.25)	1.47 (0.10)	1.21 (0.09)	1.29 (0.10)	32.67 (4.56)
'De Valero' (sw)	3.42 (0.20)	1.45 (0.07)	1.26 (0.09)	1.47 (0.06)	32.73 (2.97)
'Del País 1' (sw)	3.07 (0.28)	1.38 (0.12)	1.04 (0.18)	1.39 (0.09)	37.77 (3.21)
'Del País 2' (sw)	2.95 (0.32)	1.33 (0.15)	0.96 (0.26)	1.37 (0.08)	36.50 (2.60)
'Del País T' (sw)	3.15 (0.26)	1.41 (0.12)	1.03 (0.23)	1.38 (0.05)	35.27 (2.47)
'Del Valle' (sw)	3.28 (0.22)	1.42 (0.13)	1.17 (0.18)	1.31 (0.11)	25.89 (4.31)
'Garrafal Napoleón' (sw)	3.81 (0.26)	1.69 (0.14)	1.37 (0.11)	1.46 (0.03)	35.44 (3.88)
'Guindo del País 1' (so)	2.55 (0.26)	1.09 (0.09)	1.00 (0.14)	1.09 (0.11)	28.35 (2.78)
'Guindo del País 2' (so)	3.11 (0.31)	1.29 (0.14)	1.28 (0.17)	1.38 (0.10)	27.60 (3.24)
'Guindo Garrafal Negro' (so)	3.16 (0.26)	1.26 (0.10)	1.23 (0.13)	1.38 (0.10)	29.42 (2.91)
'Guindo Tomatillo 1' (so)	3.04 (0.46)	1.26 (0.17)	1.19 (0.19)	1.35 (0.11)	27.86 (2.61)
'Guindo Tomatillo 2' (so)	3.40 (0.19)	1.46 (0.08)	1.51 (0.09)	1.37 (0.14)	24.14 (1.39)
'Jarandilla' (sw)	3.44 (0.25)	1.44 (0.13)	1.05 (0.13)	1.49 (0.06)	32.63 (2.50)
'Lamper' (sw)	3.55 (0.26)	1.53 (0.11)	1.20 (0.13)	1.48 (0.09)	33.34 (3.10)
'Mollar' (sw)	3.39 (0.36)	1.47 (0.20)	1.22 (0.25)	1.56 (0.09)	33.20 (4.89)
'Monzón' (sw)	3.75 (0.34)	1.62 (0.15)	1.34 (0.21)	1.52 (0.10)	31.77 (2.87)
'Moracha' (sw)	3.47 (0.18)	1.52 (0.09)	1.32 (0.12)	1.53 (0.09)	33.09 (2.78)
'Pedro Merino' (sw)	3.20 (0.30)	1.35 (0.15)	1.27 (0.25)	1.53 (0.13)	30.34 (3.45)
'Pical' (sw)	3.70 (0.31)	1.63 (0.15)	1.39 (0.17)	1.73 (0.15)	33.23 (3.42)
'Pico Negro' (sw)	3.19 (0.29)	1.37 (0.12)	0.96 (0.10)	1.30 (0.08)	32.14 (4.14)
'Picota' (sw)	3.30 (0.23)	1.44 (0.13)	1.07 (0.09)	1.40 (0.08)	30.40 (3.55)
'Rabo Largo Negra' (sw)	3.44 (0.26)	1.49 (0.10)	1.27 (0.19)	1.43 (0.06)	30.77 (3.68)
'Ramón Oliva' (sw)	3.67 (0.30)	1.58 (0.13)	1.31 (0.16)	1.47 (0.06)	33.09 (3.51)
'Reondal' (sw)	3.74 (0.13)	1.64 (0.06)	1.54 (0.11)	1.41 (0.07)	34.99 (3.19)

Table 3. Main parameters of flower, leaf and fruit in sweet (*P. avium*), duke (*P.* × *gondouinii*) and sour (*P. cerasus*) cherry species

	***A posteriori* species assignation**				
	P. avium			***P.* × *gondouinii***	***P. cerasus***
	Local cultivar	**Improved cultivars**	**Mean**		
Open flower diameter (cm)	3.42[1]	3.62[2]	3.52[a]	3.18[b]	2.55[c]
Pistil length (cm)	1.44[1]	1.48[1]	1.46[a]	1.37[a]	1.09[b]
Number of stamens	33.071	33.84[1]	33.46[a]	27.26[b]	28.35[b]
Petiole length (cm)	4.79[1]	3.89[2]	4.34[a]	3.54[b]	2.06[c]
Length/width ratio of the blade	1.97[1]	2.19[2]	2.08[a]	1.87[a]	2.02[a]
Stalk length (cm)	4.96[1]	3.80[2]	4.38[a]	4.24[a]	3.34[a]
Fruit volume (cm^3)	4.35[1]	5.97[2]	5.16[a]	3.82[ab]	2.47[b]
Endocarp volume (cm^3)	0.47[1]	0.46[1]	0.46[a]	0.39[a]	0.26[b]
Weight 100 fruits (g)	455.35[1]	676.38[2]	565.86[a]	450.49[ab]	320.21[b]
Total soluble solids (°Brix)	19.68[1]	16.78[2]	18.75[a]	17.20[ab]	15.33[b]
Titratable acidity (g/100 g)[#]	0.46[1]	0.47[1]	0.46[a]	0.69[b]	1.37[c]

[a-c] Letters indicate the statistically significant differences between *Prunus avium* L., *Prunus* × *gondouinii* Rehd. and *Prunus cerasus* L. at the 95% confidence level. [1-2] Numbers indicate the statistically significant differences between local and improved sweet cherry cultivars at the 95% confidence level. [#] Grams of malic acid per 100 grams fresh weight.

Figure 1. Comparison of flower size of sweet cherry cultivars 'Monzón' (improved, left) and 'Del País 2' (local, right).

Table 4. Leaf parameters in sweet (sw) (*P. avium*) and sour (so) (*P. cerasus*) cherry cultivars, including (SD)

Cultivar	1	2	3	4	5	6	7	8
	Petiole length (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Apical angle (°)	Basal angle (°)	2/3 ratio	1/2 ratio	Anthocyanin coloration of leaf glands
'Ambrunés Especial' (sw)	4.59 (0.63)	12.51 (1.26)	5.98 (0.73)	38.84 (3.19)	87.45 (1.64)	2.11 (0.18)	0.37 (0.05)	Reddish
'Aragonesa' (sw)	3.88 (0.23)	15.58 (0.10)	6.53 (0.44)	36.90 (4.17)	159.19 (0.92)	2.41 (0.16)	0.25 (0.02)	Red
'Blanca de Provenza' (sw)	3.45 (0.45)	14.11 (1.78)	6.44 (0.76)	63.31 (6.27)	137.62 (14.02)	2.21 (0.24)	0.25 (0.04)	Green
'Boba' (sw)	3.60 (0.21)	14.47 (0.75)	6.20 (0.80)	38.95 (1.42)	149.05 (1.86)	2.37 (0.19)	0.25 (0.02)	Reddish
'Burlat' (sw)	4.15 (0.73)	13.26 (1.55)	5.96 (0.49)	44.65 (5.88)	144.73 (8.17)	2.24 (0.21)	0.32 (0.05)	Reddish
'California' (sw)	3.38 (0.33)	15.52 (1.38)	7.35 (0.59)	59.06 (6.02)	138.41 (14.39)	2.08 (0.23)	0.24 (0.05)	Reddish
'Corazón Serrano' (sw)	4.07 (0.44)	13.35 (1.34)	6.49 (0.72)	40.70 (5.64)	100.02 (10.67)	2.08 (0.20)	0.31 (0.04)	Red
'Costalera' (sw)	4.82 (0.32)	12.64 (0.87)	6.21 (0.45)	34.29 (3.66)	87.22 (2.17)	2.05 (0.08)	0.39 (0.04)	Red
'De Valero' (sw)	5.44 (0.47)	13.70 (1.13)	8.00 (0.58)	42.10 (3.27)	120.97 (5.49)	1.72 (0.12)	0.40 (0.03)	Red
'Del País 1' (sw)	3.81 (0.27)	12.98 (0.72)	6.54 (0.69)	35.76 (1.62)	126.52 (3.16)	1.99 (0.12)	0.29 (0.03)	Reddish
'Del País 2' (sw)	3.55 (0.59)	11.35 (1.53)	6.21 (0.76)	39.13 (2.24)	122.06 (9.18)	1.83 (0.11)	0.32 (0.05)	Reddish
'Del País T' (sw)	3.98 (0.63)	13.31 (1.44)	6.39 (0.87)	27.76 (5.18)	127.21 (8.77)	2.11 (0.18)	0.30 (0.04)	Reddish
'Del Valle' (sw)	4.69 (0.50)	11.05 (1.05)	6.34 (0.84)	35.86 (2.97)	94.73 (11.73)	1.75 (0.09)	0.43 (0.03)	Red
'Garrafal Napoleón' (sw)	3.87 (0.39)	16.68 (0.92)	7.04 (0.36)	48.22 (5.61)	157.29 (5.57)	2.37 (0.16)	0.23 (0.02)	Red
'Guindo del País 1' (so)	2.06 (0.34)	8.96 (0.82)	4.47 (0.48)	44.67 (4.06)	119.71 (9.34)	2.02 (0.10)	0.23 (0.04)	Green
'Guindo del País 2' (so)	3.25 (0.09)	10.67 (0.73)	5.11 (0.09)	37.95 (1.32)	119.18 (1.98)	2.11 (0.13)	0.31 (0.02)	Reddish
'Guindo Garrafal Negro' (so)	3.17 (0.40)	10.45 (0.95)	5.40 (0.48)	44.58 (1.59)	111.98 (2.39)	1.95 (0.13)	0.31 (0.04)	Reddish
'Guindo Tomatillo 1' (so)	3.89 (0.69)	11.19 (1.77)	6.29 (0.96)	36.53 (6.82)	129.53 (8.04)	1.80 (0.27)	0.36 (0.07)	Reddish
'Guindo Tomatillo 2' (so)	3.85 (0.32)	10.97 (0.88)	6.78 (0.43)	47.58 (2.27)	123.92 (2.07)	1.63 (0.11)	0.35 (0.03)	Reddish
'Jarandilla' (sw)	5.18 (0.40)	13.29 (1.05)	7.30 (0.50)	25.86 (2.60)	91.46 (2.69)	1.83 (0.11)	0.39 (0.02)	Reddish
'Lamper' (sw)	4.18 (0.39)	11.82 (0.75)	6.07 (0.34)	41.88 (2.02)	140.54 (3.91)	1.96 (0.06)	0.36 (0.04)	Green
'Mollar' (sw)	5.43 (0.43)	12.14 (0.57)	6.19 (0.54)	40.66 (1.34)	87.22 (2.58)	1.98 (0.16)	0.45 (0.02)	Red
'Monzón' (sw)	3.91 (0.62)	14.22 (1.23)	6.62 (0.54)	39.77 (6.07)	130.21 (20.14)	2.16 (0.17)	0.28 (0.06)	Reddish
'Moracha' (sw)	6.40 (1.03)	13.65 (1.10)	7.60 (0.57)	45.88 (1.98)	125.07 (3.64)	1.81 (0.09)	0.47 (0.05)	Red
'Pedro Merino' (sw)	4.16 (0.31)	12.81 (1.07)	6.31 (0.49)	33.84 (3.73)	158.00 (1.81)	2.05 (0.20)	0.33 (0.02)	Red
'Pical' (sw)	5.05 (0.37)	13.15 (0.95)	7.68 (0.30)	52.63 (4.43)	139.29 (2.59)	1.71 (0.06)	0.39 (0.04)	Red
'Pico Negro' (sw)	4.86 (0.74)	12.90 (0.75)	6.47 (0.69)	31.90 (3.84)	105.36 (9.81)	2.01 (0.15)	0.38 (0.05)	Red
'Picota' (sw)	4.95 (0.66)	12.48 (2.42)	5.92 (0.91)	37.42 (8.51)	110.84 (6.00)	2.11 (0.24)	0.40 (0.03)	Red
'Rabo Largo Negra' (sw)	5.27 (0.11)	12.91 (1.16)	7.40 (0.63)	46.35 (1.62)	123.80 (2.87)	1.74 (0.01)	0.41 (0.03)	Red
'Ramón Oliva' (sw)	4.82 (0.53)	14.17 (1.01)	6.44 (0.92)	36.44 (6.36)	137.68 (3.00)	2.25 (0.28)	0.35 (0.04)	Red
'Reondal' (sw)	5.29 (0.67)	13.33 (1.47)	6.38 (0.58)	39.23 (2.48)	125.10 (1.66)	2.10 (0.18)	0.40 (0.03)	Red

25° to 63°. The shortest petioles were in sour cherries ('Guindo del País 1'), at about 2.0 cm, and the longest in 'De Valero' and 'Moracha' sweet cherries, at 6.4 and 5.4 cm, respectively. Blade size was large in all sweet cherries, with a length of 11 to 16 cm and a width of 6 to 8 cm. In sour cherries the same parameters varied from 9 to 11 cm and from 4 to 6 cm, respectively. The length/width ratio of the leaf blades ranged from 1.71 to 2.41 in sweet cherries. 'Aragonesa', 'Boba' and 'Garrafal Napoleón' were the cultivars with the highest ratio, and the ratio ranged from 1.63 to 2.11 in the sour cherries. The other ratios calculated (petiole/leaf blade length) had values of around 0.35 in sweet cherry and 0.31 in sour cherry. 'Guindo del País 1' had the lowest petiole/leaf blade length ratio, at around 0.23.

Generally, leaf parameters such as petiole length and blade length were variable over the 3 years of the study because of climate variation. Standard deviations of the means of petiole length and blade length during the period of study were 0.79 and 1.45 in sweet cherry and 0.41 and 0.61 in sour cherry, respectively.

In sweet cherry cultivars there were clear differences among genetically improved and local cultivars (Table 3). Genetically improved cultivars such as 'Burlat', 'Monzón' and 'Garrafal Napoleón' had leaves with short petioles and a large foliar surface area. The sweet cherry cv. 'Garrafal Napoleón' had a mean blade length of 16.68 cm, a mean blade width of 7.04 cm and a mean petiole length of 3.87 cm. These cultivars were also characterized by having leaves with a spear-like or elongate elliptical shape, in which the base of the blade was rounded and its tip was pointed. On the other hand, the local cv. 'Del Valle' had leaves with a pointed blade bases and sharply pointed tip. These leaves were also smaller: with a mean blade length 11.05 cm; mean blade width 6.34 cm and a mean petiole length of 4.69 cm. Leaves of both cherry cultivars can be seen in Figure 2. Analysing sour cherry tree leaves, it was observed that 'Guindo Tomatillo 1', 'Guindo Tomatillo 2', 'Guindo del País 2' and 'Guindo Garrafal Negro' had significantly larger leaves than the other sour cherry cultivar studied, 'Guindo del País 1'. In sour cherry cv. 'Garrafal Negra', Cordeiro (2004) observed mean leaf values similar to those reported here: blade length 11.99 cm, blade width 5.87 cm and petiole length 2.98 cm. 'Guindo del País 1' was the only cultivar with green nectaries, the other sour cherry cultivars having slightly reddish coloured nectaries.

Fruits

Quantitative fruit parameters are shown in Table 5. Stalk length ranged from 3.09 to 6.90 cm in sweet cherry. 'De Valero' and 'Moracha' were the cultivars with the longest stalk. Stalk length was 3.34 to 4.81 cm in the sour cherry.

'Corazón Serrano' was the sweet cherry cultivar with the largest fruits, at 8.56 cm^3 fruit volume, 24.95 mm mean geometric diameter and 19.68 cm^2 fruit surface area. 'Guindo del País 1' was the cultivar with the smallest fruits: fruit volume of 2.47 cm^3, mean geometric diameter 16.57 mm, and fruit surface area of 8.68 cm^2. The other sour cherry cultivars also had quite small fruits compared to the sweet cherries. Endocarp volume varied from 0.30 to 0.60 cm^3 in sweet cherry and from 0.26 to 0.47 in sour cherry. 'Guindo del País 1' was the sour cherry cultivar with smallest endocarp. 'Corazón Serrano', 'Monzón', 'Boba', 'California' and 'Ambrunés Especial' were sweet cherry cultivars with the greatest pulp volume.

Figure 2. Comparison of petiole length, blade length and leaf width in sweet cherry cultivars 'Garafal Napoleón' (improved, left) and 'Del Valle' (local, right). Scale in cm.

Table 5. Quantitative fruit parameters in sweet (sw) (*P. avium*) and sour (so) (*P. cerasus*) cherry cultivars, including (SD)

	1	2	3	4	5	6	7	8
Cultivar	**Stalk length (cm)**	**Fruit length (cm)**	**Fruit width (cm)**	**Fruit thickness (cm)**	**Fruit volume (cm^3)**	**Geometric mean diameter (mm)**	**Fruit surface area (cm^2)**	**Sphericity (%)**
'Ambrunés Especial' (sw)	3.19 (0.27)	2.37 (0.15)	2.42 (0.28)	2.04 (0.09)	6.25 (1.14)	22.58 (1.31)	16.08 (1.88)	95.62 (4.59)
'Aragonesa' (sw)	4.39 (0.29)	2.14 (0.16)	2.19 (0.26)	1.89 (0.15)	4.77 (0.92)	20.60 (1.25)	13.45 (1.61)	96.36 (3.24)
'Blanca de Provenza' (sw)	3.89 (0.40)	2.08 (0.21)	2.24 (0.28)	2.13 (0.14)	5.37 (1.45)	21.43 (1.78)	14.54 (2.50)	102.97 (2.44)
'Boba' (sw)	3.85 (0.34)	2.30 (0.15)	2.46 (0.24)	2.16 (0.12)	6.53 (1.02)	22.90 (1.63)	16.54 (1.31)	100.46 (4.69)
'Burlat' (sw)	3.09 (0.51)	2.27 (0.18)	2.36 (0.23)	1.91 (0.14)	5.55 (1.20)	21.64 (1.57)	14.81 (2.12)	95.33 (3.60)
'California' (sw)	4.57 (0.20)	2.22 (0.07)	2.56 (0.03)	2.27 (0.10)	6.87 (0.53)	23.41 (0.61)	17.25 (0.91)	105.35 (0.78)
'Corazón Serrano' (sw)	4.20 (0.53)	2.69 (0.20)	2.71 (0.30)	2.16 (0.16)	8.56 (1.99)	24.95 (1.83)	19.68 (2.93)	92.69 (2.77)
'Costalera' (sw)	5.10 (0.34)	2.24 (0.07)	2.05 (0.08)	1.70 (0.29)	4.22 (0.67)	19.70 (1.33)	12.27 (1.60)	88.33 (7.27)
'De Valero' (sw)	6.68 (0.76)	2.05 (0.10)	2.01 (0.07)	1.72 (0.18)	3.77 (0.53)	19.11 (0.92)	11.51 (1.12)	93.44 (3.20)
'Del País 1' (sw)	4.03 (0.36)	1.98 (0.14)	1.81 (0.21)	1.74 (0.12)	3.34 (0.95)	18.33 (1.06)	10.63 (1.95)	92.53 (3.52)
'Del País 2' (sw)	4.02 (0.25)	1.89 (0.18)	1.79 (0.17)	1.77 (0.13)	3.21 (0.77)	18.09 (1.43)	10.35 (1.64)	95.86 (3.73)
'Del País T' (sw)	4.56 (0.51)	1.76 (0.14)	1.66 (0.16)	1.62 (0.16)	2.54 (0.71)	16.73 (1.50)	8.86 (1.62)	94.84 (1.61)
'Del Valle' (sw)	4.42 (0.40)	1.91 (0.24)	1.99 (0.16)	1.60 (0.23)	3.26 (0.57)	18.09 (1.15)	10.33 (1.31)	95.77 (7.76)
'Garrafal Napoleón' (sw)	3.56 (0.18)	2.46 (0.11)	2.43 (0.01)	1.98 (0.04)	6.28 (0.23)	22.66 (0.23)	16.14 (0.34)	92.39 (2.93)
'Guindo del País 1' (so)	3.34 (0.48)	1.58 (0.13)	1.76 (0.18)	1.66 (0.15)	2.47 (0.59)	16.57 (1.29)	8.68 (1.37)	105.20 (4.02)
'Guindo del País 2' (so)	4.36 (0.33)	1.78 (0.21)	2.09 (0.22)	1.85 (0.19)	3.63 (0.72)	18.90 (1.43)	11.24 (1.52)	107.01 (4.96)
'Guindo Garrafal Negro' (so)	3.80 (0.38)	1.82 (0.09)	2.21 (0.13)	1.64 (0.11)	3.55 (0.35)	18.64 (0.68)	10.95 (0.78)	102.71 (3.68)
'Guindo Tomatillo 1' (so)	4.00 (0.39)	1.96 (0.26)	2.19 (0.24)	2.06 (0.18)	4.72 (0.93)	20.49 (1.33)	13.28 (1.74)	105.99 (10.70)
'Guindo Tomatillo 2' (so)	4.81 (0.41)	1.55 (0.19)	2.17 (0.27)	1.84 (0.16)	3.37 (0.65)	18.28 (1.29)	10.54 (1.26)	118.55 (5.64)
'Jarandilla' (sw)	4.19 (0.55)	2.05 (0.15)	2.13 (0.22)	1.71 (0.07)	4.04 (0.81)	19.45 (1.23)	11.96 (1.52)	95.13 (1.97)
'Lamper' (sw)	4.33 (0.33)	2.13 (0.19)	2.29 (0.30)	1.92 (0.13)	5.04 (1.13)	20.96 (1.57)	13.89 (2.04)	98.60 (4.85)
'Mollar' (sw)	5.63 (0.49)	2.32 (0.25)	2.35 (0.24)	1.99 (0.12)	5.83 (1.34)	22.02 (1.72)	15.33 (2.33)	95.35 (3.88)
'Monzón' (sw)	3.94 (0.46)	2.36 (0.18)	2.35 (0.19)	1.99 (0.20)	5.89 (1.08)	22.11 (1.36)	15.43 (1.89)	94.06 (5.17)
'Moracha' (sw)	6.90 (0.56)	2.07 (0.06)	2.12 (0.15)	1.73 (0.10)	4.07 (0.40)	19.56 (0.62)	12.07 (0.77)	94.78 (2.92)
'Pedro Merino' (sw)	3.91 (0.49)	2.17 (0.15)	2.32 (0.33)	1.80 (0.14)	4.87 (0.63)	20.69 (0.72)	13.49 (0.94)	95.71 (4.50)
'Pical' (sw)	5.20 (0.55)	2.27 (0.12)	2.11 (0.09)	1.78 (0.19)	4.61 (0.54)	20.33 (0.88)	13.05 (1.12)	89.75 (5.35)
'Pico Negro' (sw)	4.72 (0.36)	2.38 (0.23)	2.11 (0.08)	1.72 (0.24)	4.68 (0.48)	20.36 (0.80)	13.06 (1.02)	86.75 (8.92)
'Picota' (sw)	4.21 (0.26)	1.93 (0.15)	2.04 (0.14)	1.91 (0.12)	4.01 (0.67)	19.49 (1.18)	12.01 (1.40)	101.41 (3.37)
'Rabo Largo Negra' (sw)	6.16 (0.38)	2.05 (0.19)	2.02 (0.18)	1.67 (0.10)	3.66 (0.53)	18.92 (1.02)	11.26 (1.49)	93.00 (6.23)
'Ramón Oliva' (sw)	4.15 (0.68)	2.16 (0.27)	2.25 (0.23)	1.74 (0.30)	4.69 (1.54)	20.23 (2.46)	13.06 (3.06)	94.13 (2.24)
'Reondal' (sw)	5.74 (0.32)	2.11 (0.19)	2.25 (0.39)	1.83 (0.08)	4.74 (1.41)	20.45 (1.88)	13.26 (2.47)	101.02 (2.49)

At the other extreme were cvs. 'Jarandilla' and 'Rabo Largo Negra', with an endocarp volume/fruit volume ratio of about 0.14. In sour cherries, this ratio varied from 0.09 to 0.14. 'Burlat' and 'Pedro Merino' were the sweet cherry cultivars with the heaviest fruits, with a mean fruit weight of 8.28 and 8.05 g respectively. This contrasts with cvs. 'Del Valle' and 'Del País 1', with fruits of 3.05 and 3.17 g, respectively. Fruit of 'Guindo del País 1' had a mean weight of 3.20 g per unit.

Percentage of cracked fruit was variable among the different cultivars. 'Corazón Serrano' was the sweet cherry cultivar that cracked most, cracking percentage approximately 42.67%, and 'Rabo Largo Negra' was the cultivar most resistant to cracking. Some sour cherry cultivars were also significantly resistant to cracking, such as 'Guindo Garrafal Negro' and 'Guindo del País 1', with cracking percentages of < 5%.

Titratable acidity was 0.38 to 0.63 g/100 g in sweet cherry and 0.62 to 1.37 g/100 g in sour cherry. 'Guindo del País 1' was the sour cherry cultivar with the highest fruit acidity. Soluble solids levels showed less variation and, in all cases, ranged from 15 to 23°Brix.

Generally, fruit parameters such as stalk length and fruit volume varied over the three years of the studied due to marked climatic variation. Standard deviations of the means for stalk length and fruit volume during the study were 1.03 and 1.48 in sweet cherry and 0.53 and 0.84 in sour cherry, respectively.

Analysing different fruit parameters of the sweet cherry, improved cultivars could be clearly distinguished

Table 5 (cont.). Quantitative fruit parameters in sweet (sw) (*P. avium*) and sour (so) (*P. cerasus*) cherry cultivars, including (SD)

	9	10	11	12	13	14	15	16	17
Cultivar	**Endocarp length (cm)**	**Endocarp width (cm)**	**Endocarp thickness (cm)**	**Endocarp volume (cm^3)**	**Weight 100 fruits (g)**	**12/5 ratio**	**Cracking (%)**	**Total soluble solids (°Brix)**	**Titratable acidity (g/100 g)[#]**
'Ambrunés Especial' (sw)	1.16 (0.04)	0.94 (0.04)	0.71 (0.04)	0.43 (0.04)	706.69	0.07 (0.01)	15.83	16.36 (1.64)	0.54 (0.03)
'Aragonesa' (sw)	1.21 (0.08)	1.01 (0.04)	0.77 (0.04)	0.55 (0.07)	472.03	0.11 (0.01)	26.67	18.12 (2.16)	0.42 (0.08)
'Blanca de Provenza' (sw)	1.09 (0.09)	0.96 (0.06)	0.75 (0.08)	0.44 (0.11)	593.11	0.08 (0.01)	11.67	16.48 (0,99)	0.42 (0.07)
'Boba' (sw)	1.23 (0.09)	0.89 (0.05)	0.71 (0.05)	0.45 (0.08)	744.55	0.07 (0.01)	23.33	17.68 (1.43)	0.49 (0.03)
'Burlat' (sw)	1.25 (0.09)	0.98 (0.07)	0.69 (0.06)	0.49 (0.08)	828.61	0.09 (0.02)	28.06	15.46 (1.32)	0.49 (0.02)
'California' (sw)	1.08 (0.04)	1.02 (0.02)	0.82 (0.03)	0.48 (0.02)	720.86	0.07 (0.01)	15.00	14.87 (0.88)	0.49 (0.02)
'Corazón Serrano' (sw)	1.28 (0.07)	1.08 (0.08)	0.78 (0.05)	0.60 (0.09)	520.35	0.07 (0.02)	42.67	17.96 (1.68)	0.39 (0.06)
'Costalera' (sw)	1.28 (0.03)	0.93 (0.08)	0.68 (0.07)	0.47 (0.07)	520.96	0.11 (0.01)	8.00	21.92 (2.77)	0.48 (0.09)
'De Valero' (sw)	1.21 (0.09)	0.92 (0.07)	0.68 (0.08)	0.44 (0.06)	392.80	0.12 (0.02)	16.67	19.21 (2.75)	0.48 (0.06)
'Del País 1' (sw)	1.14 (0.08)	0.86 (0.06)	0.63 (0.05)	0.38 (0.07)	317.74	0.11 (0.01)	10.00	20.56 (3.12)	0.54 (0.05)
'Del País 2' (sw)	1.07 (0.12)	0.85 (0.10)	0.66 (0.06)	0.35 (0.11)	393.42	0.11 (0.01)	17.78	20.94 (2.96)	0.58 (0.09)
'Del País T' (sw)	1.03 (0.08)	0.81 (0.08)	0.64 (0.07)	0.30 (0.08)	352.23	0.12 (0.02)	25.00	18.40 (2.24)	0.40 (0.04)
'Del Valle' (sw)	1.11 (0.06)	0.95 (0.08)	0.66 (0.03)	0.39 (0.05)	305.93	0.13 (0.03)	17.76	18.03 (2.57)	0.38 (0.10)
'Garrafal Napoleón' (sw)	1.24 (0.01)	0.89 (0.08)	0.83 (0.01)	0.51 (0.04)	652.36	0.08 (0.00)	24.00	18.04 (1.34)	0.41 (0.05)
'Guindo del País 1' (so)	0.88 (0.08)	0.83 (0.08)	0.64 (0.07)	0.26 (0.06)	320.21	0.11 (0.02)	5.00	15.34 (1.95)	1.37 (0.03)
'Guindo del País 2' (so)	0.96 (0.11)	0.93 (0.07)	0.70 (0.07)	0.34 (0.07)	426.66	0.10 (0.01)	21.15	17.05 (1.73)	0.62 (0.02)
'Guindo Garrafal Negro' (so)	1.00 (0.10)	0.87 (0.07)	0.69 (0.07)	0.33 (0.04)	441.23	0.10 (0.02)	4.17	17.52 (1.12)	0.78 (0.02)
'Guindo Tomatillo 1' (so)	0.98 (0.18)	1.01 (0.07)	0.80 (0.09)	0.43 (0.09)	461.38	0.09 (0.02)	18.61	17.26 (1.68)	0.67 (0.03)
'Guindo Tomatillo 2' (so)	1.10 (0.10)	0.93 (0.07)	0.83 (0.06)	0.47 (0.06)	472.70	0.14 (0.01)	26.67	16.95 (2.01)	0.69 (0.04)
'Jarandilla' (sw)	1.29 (0.08)	1.00 (0.07)	0.72 (0.07)	0.54 (0.08)	354.52	0.14 (0.03)	40.00	19.60 (2.08)	0.40 (0.11)
'Lamper' (sw)	1.10 (0.04)	0.97 (0.05)	0.70 (0.03)	0.42 (0.04)	600.62	0.08 (0.00)	15.83	17.08 (1.72)	0.39 (0.04)
'Mollar' (sw)	1.27 (0.06)	0.91 (0.06)	0.70 (0.06)	0.47 (0.05)	608.31	0.09 (0.03)	20.00	23.72 (2.93)	0.46 (0.07)
'Monzón' (sw)	1.23 (0.09)	0.87 (0.06)	0.68 (0.08)	0.42 (0.07)	564.26	0.07 (0.01)	22.49	18.29 (1.14)	0.50 (0.03)
'Moracha' (sw)	1.26 (0.08)	0.95 (0.04)	0.71 (0.03)	0.49 (0.05)	433.32	0.12 (0.02)	17.22	19.84 (2.41)	0.45 (0.09)
'Pedro Merino' (sw)	1.11 (0.06)	0.99 (0.06)	0.69 (0.04)	0.43 (0.04)	805.68	0.09 (0.01)	80.00	16.12 (1.87)	0.61 (0.05)
'Pical' (sw)	1.39 (0.10)	0.95 (0.04)	0.71 (0.04)	0.56 (0.07)	450.41	0.13 (0.02)	8.33	22.53 (2.69)	0.53 (0.09)
'Pico Negro' (sw)	1.30 (0.06)	0.90 (0.05)	0.64 (0.05)	0.45 (0.05)	575.74	0.10 (0.01)	9.44	20.28 (2.86)	0.63 (0.08)
'Picota' (sw)	1.15 (0.07)	1.00 (0.05)	0.78 (0.04)	0.49 (0.08)	462.85	0.12 (0.01)	16.67	20.24 (2.04)	0.48 (0.08)
'Rabo Largo Negra' (sw)	1.28 (0.07)	0.97 (0.06)	0.68 (0.05)	0.49 (0.07)	401.54	0.14 (0.01)	0.00	18.98 (2.68)	0.46 (0.11)
'Ramón Oliva' (sw)	1.28 (0.09)	1.08 (0.09)	0.66 (0.23)	0.55 (0.16)	577.96	0.12 (0.02)	36.67	17.84 (2.01)	0.40 (0.09)
'Reondal' (sw)	1.30 (0.12)	0.98 (0.09)	0.72 (0.08)	0.53 (0.06)	600.79	0.12 (0.04)	14.17	16.36 (2.79)	0.38 (0.06)

[#] Grams of malic acid per 100 grams fresh weight.

from local cultivars (Table 3). Introduced, genetically improved cultivars have a short peduncle and large fruits, with a lot of pulp and an eye-catching appearance. However, they were more prone to cracking. The data in our study is in accordance with that of Moreno and Manzano (2002) for cvs. 'Burlat', 'California', 'Pico Colorado' and 'Pico Negro'.

Local cultivars generally had long fruit peduncles, which made harvesting more difficult, small-sized fruits with little pulp, and were less eye-catching. They did have the advantage of being significantly more resistant to cracking than cultivars with a large pulp volume. Revilla and Vivar (2004) also observed that sweet and sour cherry cultivars showed great variability in fruit parameters such as skin firmness and pulp hardness. Cultivars with lower skin firmness and pulp hardness levels had lower fruit cracking. In 'Rabo Largo Negra' the mean cracking percentage was 0%. It would be interesting to use this fruit cracking tolerant cultivar in future breeding programs.

'Corazón Serrano', despite being a local cultivar from the Sierra de Francia, had fruit parameters significantly more similar to those of improved sweet cherry cultivars. This can be confirmed by observing some of its mean fruit data: peduncle length 4.20 cm and endocarp size/fruit size ratio 0.07. This cultivar has probably been

improved through local growers over hundreds of years. Its main disadvantage is that is very prone to cracking (42.67%). Cordeiro *et al.* (2007) also observed that in different sweet and sour cherry cultivars it is difficult to combine yield, fruit size and cracking tolerance.

With regard to sphericity, the cvs. 'Pico Negro' and 'Costalera', which are generically known as «picotas» in the Jerte valley, were the cultivars with the most elongated fruit, and 'California', was the cultivar with the most flattened fruit. MAPA (1999), Gella *et al.* (2001) and Moreno and Trujillo (2006) also observed elongated/heart-shaped fruits in 'Pico Negro', and kidney-shaped fruit in cv. 'California'. Vursavuş *et al.* (2006) recorded sphericity values for cv. 'Monzón' similar to those recorded here (90.66%).

'Pedro Merino' was, after 'Burlat', the sweet cherry cultivar with the heaviest fruits (8.05 g per unit). Moreno and Manzano (2002) recorded a mean fruit weight, for this cultivar, between 7.0 and 7.5 g.

For sour cherry, important differences were among the fruit of 'Guindo del País 1' and the other sour cherries studied. Fruit of this cultivar was smaller, sourer and had shorter peduncles than those of the other sour cherry cultivars. 'Guindo Tomatillo 1' was the sour cherry cultivar with the largest fruit (4.72 cm^3). This contrasts with the 2.47 cm^3 of the cv. 'Guindo del País 1' (see fruit of both cultivars in Fig. 3).

Lowest fruit-cracking percentages in sour cherry were in 'Guindo del País 1' and 'Guindo Garrafal Negro', at 5.00 and 4.17 % respectively. For the other sour cherry cultivars mean cracking values were close to 22%. This is similar to values in sweet cherry cultivars. Sour cherries, in all cases, had a flattened shape, with sphericity values > 102.71%. 'Guindo del País 1' was the sour cherry cultivar with the lightest fruits (3.20 g per unit). For the other sour cherry cultivars mean fruit weights were between 4.26 and 4.72 g.

With respect to qualitative fruit characteristics there was remarkable variation among cultivars (Table 6). Some of the sweet cherry cultivars had fruit with a practically black skin, and a red pulp. This was the case with 'Rabo Largo Negra', 'De Valero', 'Moracha' and 'Reondal', whereas others, such as 'Blanca de Provenza', had fruit with a yellow skin and white/cream-coloured pulp. Juice colour in sweet cherry varied from colourless to purple. Generally all the sweet cherry cultivars studied had fruit without leaves at the peduncle and with slight skin discoloration. In sweet cherry, diverse fruit shapes and endocarp were observed. In sour cherry all cultivars had flattened fruit with quite rounded endocarps, and even/concave pistil points. 'Guindo Garrafal Negro' was the cultivar that exhibited the greatest differences compared to the other sour cherry cultivars. Its skin is dark (purple-black) and its pulp and juice are red to purple. 'Guindo del País 1', 'Guindo del País 2', 'Guindo Tomatillo 1' and 'Guindo Tomatillo 2' have white/cream-coloured pulp, colourless juice and a mid reddish coloured skin. In the sour cherry cultivars leaves at the peduncle were fairly frequently observed.

Vegetative tree habit

Tree evaluation is summarised in Table 7. In sweet cherry trees, very diverse vegetative habits were

Figure 3. Comparison of stalk length and fruit volume in cherry cultivars 'Guindo del País 1' (left) and 'Guindo Tomatillo 1' (right).

Table 6. Qualitative fruit parameters in sweet (sw) (*P. avium* L.) and sour (so) (*P. cerasus* L.) cherry cultivars

	1	2	3	4	5	6	7	8
Cultivar	**Skin colour**	**Pulp colour**	**Fruit juice colour**	**Fruit shape**	**Endocarp shape**	**Pistilar point shape**	**External discoloration**	**Leaves on fruit stalk**
'Ambrunés Especial' (sw)	Mahogany	Pink	Red	Kidney shaped / Flat-round	Round-elongate	Concave-even	Weak	None
'Aragonesa' (sw)	Mahogany	Purple	Purple	Kidney shaped / Flat-round	Round-elongate	Concave-even	Weak	None
'Blanca de Provenza' (sw)	Yellow	Cream-white	Colourless	Flat-round / round	Elongate	Even	Weak	None
'Boba' (sw)	Vermillion on yellow ground colour	Cream-white	Colourless	Elongate-cordate	Elongate	Concave-even	Strong	None
'Burlat' (sw)	Mahogany	Pink	Purple	Kidney shape / Flat-round	Elongate	Concave	Weak	None
'California' (sw)	Mahogany	Red	Red	Kidney-shaped	Round-elongate	Concave	Weak	None
'Corazón Serrano' (sw)	Mahogany	Red	Red	Cordate	Round-oval	Pointed	Weak	None
'Costalera' (sw)	Vermillion	Cream-white	Colourless	Elongate-cordate	Round-elongate	Pointed	Medium	None
'De Valero' (sw)	Mahogany-black	Red	Purple	Elongate-cordate	Round-elongate	Concave-even	Weak	None
'Del País 1' (sw)	Vermillion	Cream-white	Colourless	Elongate	Round-elongate	Concave-even	Weak	None
'Del País 2' (sw)	Vermillion	Cream-white	Colourless	Elongate	Round-elongate	Concave-even	Weak	None
'Del País T' (sw)	Vermillion	Cream-white	Colourless	Elongate	Round-elongate	Concave-even	Weak	None
'Del Valle' (sw)	Mahogany-black	Purple	Red	Kidney-shaped	Round-oval	Concave-even	Weak	None
'Garrafal Napoleón' (sw)	Vermillion on yellow ground colour	Cream-white	Colourless	Elongate-cordate	Elongate	Concave-even	Strong	None
'Guindo del País 1' (so)	Vermillion	Cream-white	Colourless	Flat-round	Round	Concave-even	Weak	Few
'Guindo del País 2' (so)	Orange red	Cream-white	Colourless	Flat-round	Round	Concave-even	Medium	Few
'Guindo Garrafal Negro' (so)	Mahogany-black	Red-purple	Red-purple	Flat-round	Round	Concave-even	Weak	Few
'Guindo Tomatillo 1' (so)	Orange red	Cream-white	Colourless	Flat-round	Round	Concave-even	Medium	Few
'Guindo Tomatillo 2' (so)	Orange red	Cream-white	Colourless	Flat-round	Round	Concave-even	Medium	Few
'Jarandilla' (sw)	Mahogany	Red	Red	Kidney-shaped	Round-oval	Concave	Weak	None
'Lamper' (sw)	Vermillion on yellow ground colour	Cream-white	Colourless	Elongate-cordate	Round-oval	Concave-even	Strong	None
'Mollar' (sw)	Vermillion	Cream-white	Colourless	Kidney-shaped	Elongate	Even-pointed	Medium	None
'Monzón' (sw)	Vermillion on yellow ground colour	Cream-white	Colourless	Elongate-cordate	Elongate	Concave-even	Strong	None
'Moracha' (sw)	Mahogany-black	Red	Purple	Elongate-cordate	Round-elongate	Concave-even	Weak	None
'Pedro Merino' (sw)	Vermillion	Red	Pink	Kidney - shaped	Round-oval	Concave-even	Medium	None
'Pical' (sw)	Vermillion	Cream-white	Colourless	Cordate	Elongate	Pointed	Strong	None
'Pico Negro' (sw)	Mahogany-black	Red	Purple	Cordate	Elongate	Even	Weak	None
'Picota' (sw)	Mahogany	Cream-white	Colourless	Cordate	Round-elongate	Concave-even	Weak	None
'Rabo Largo Negra' (sw)	Mahogany-black	Red	Purple	Elongate-cordate	Round-elongate	Concave-even	Weak	None
'Ramón Oliva' (sw)	Mahogany	Purple	Purple	Kidney shaped / Flat-round	Round-elongate	Concave-even	Weak	None
'Reondal' (sw)	Mahogany-black	Red	Purple	Kidney-shaped	Round-elongate	Concave-even	Weak	None

observed, from very upright or upright to completely drooping. 'Costalera', 'Burlat' and 'Pico Negro' exhibited a habit between upright and very upright. 'Del País T' was the only sweet cherry cultivar that had a drooping growth habit. This cultivar was different from 'Del País 1' and 'Del País 2', which are generically called 'Del País' sweet cherry by local growers, due to its habit among other reasons. 'Del País 1' and 'Del País 2' also have a spreading habit. Gella *et al.* (2001) and Moreno and Manzano (2002) also observed that

Table 7. Tree habit in sweet (sw) (*P. avium* L.) and sour (so) (*P. cerasus* L.) cherry cultivars

Cultivar	Tree habit
'Ambrunés Especial' (sw)	Spreading-drooping
'Aragonesa' (sw)	Spreading-drooping
'Blanca de Provenza' (sw)	Medium-spreading
'Boba' (sw)	Spreading-drooping
'Burlat' (sw)	Upright
'California' (sw)	Medium-spreading
'Corazón Serrano' (sw)	Medium-spreading
'Costalera' (sw)	Very upright
'De Valero' (sw)	Spreading-drooping
'Del País 1' (sw)	Spreading
'Del País 2' (sw)	Spreading
'Del País T' (sw)	Drooping
'Del Valle' (sw)	Spreading
'Garrafal Napoleón' (sw)	Spreading-drooping
'Guindo del País 1' (so)	Drooping
'Guindo del País 2' (so)	Medium
'Guindo Garrafal Negro' (so)	Spreading
'Guindo Tomatillo 1' (so)	Medium
'Guindo Tomatillo 2' (so)	Medium
'Jarandilla' (sw)	Medium
'Lamper' (sw)	Medium-spreading
'Mollar' (sw)	Upright-medium
'Monzón' (sw)	Spreading-drooping
'Moracha' (sw)	Spreading-drooping
'Pedro Merino' (sw)	Spreading-drooping
'Pical' (sw)	Spreading
'Pico Negro' (sw)	Upright
'Picota' (sw)	Upright
'Rabo Largo Negra' (sw)	Spreading-drooping
'Ramón Oliva' (sw)	Spreading-drooping
'Reondal' (sw)	Medium-spreading

'Burlat', 'Pico Negro' and 'Pico Colorado' had a quite upright growth habit. In sour cherry there were also clear differences in vegetative habit among 'Guindo Tomatillo 1', 'Guindo Tomatillo 2', 'Guindo Garrafal Negro', 'Guindo del País 2' and 'Guindo del País 1'. The latter cultivar had a completely drooping or bush-like shape. The other cultivars had a medium growth habit that was more similar to that of sweet cherry trees (Fig. 4).

Duke cherry cultivars

In view of the agromorphological results obtained for the sour cherry cultivars, it seems that 'Guindo del País 1' belong to the species *P. cerasus* L., because it exhibits all of the characteristics proper to sour cherry trees, among them a completely bush-like shape. The other sour cherry cultivars studied, which had been considered *a priori* to be sour cherry cultivars, could have originated from a cross of local cultivar of *P. avium* L. × *P. cerasus* L., because tree, flower, leaf and fruit characteristics are intermediate between sweet and sour cherry (Table 3). They would therefore belong to the species currently named *Prunus* × *gondouinii* Rehd. (Faust and Suranyi, 1997; Saunier and Claverie, 2001). Tavaud *et al.* (2004) also identified 12 cultivars of *P.* × *gondouinii* Rehd. which exhibited tree and fruit characteristics that were intermediate between sweet and sour cherry.

Figure 4. Comparison of the drooping vegetative habit of cherry cultivars 'Guindo del País 1' (left) and the intermediate vegetative habit of 'Guindo Tomatillo 2' (right).

Dendrogram

Figure 5 shows a dendrogram of the relationships among the cultivars produced by analysing all of the parameters studied. In the dendrogram the cv. 'Guindo del País 1' (considered to be *P. cerasus* L.) is different from the other cultivars in this study. In turn, in this broad group of cultivars, another two sub-groups can be distinguished. One of them includes cultivars of genetically improved sweet cherry ('Burlat', 'Monzón', etc.) or local cultivars with naturally highly production characteristics (such as 'Corazón Serrano'). The other sub-group includes the cultivars of *P.* × *gondouinii* Rehd., as well as local sweet cherry cultivars from Salamanca province. By analysing the dendrogram, a series of synonymies among sweet cherry trees can also be detected. Such is the case with 'Monzón', 'Boba' and 'Garrafal Napoleón'; 'Del País 1' and 'Del País 2' and 'De Valero', 'Moracha' and 'Rabo Largo Negra'. Another two sweet cherry cultivars that showed great similarity, from a morphological point of view, were 'Ramón Oliva' and 'Aragonesa'. In this case the existence of a synonym is discarded, since both cultivars exhibited clear differences at the isoenzymatic level (data not published).

A series of homonyms were detected: 'Del País 1' or 'Del País 2' and 'Del País T' (sweet cherry), 'Guindo Tomatillo 1' and 'Guindo Tomatillo 2' (duke cherry) and 'Guindo del País 1' and 'Guindo del País 2' (sour and duke cherry).

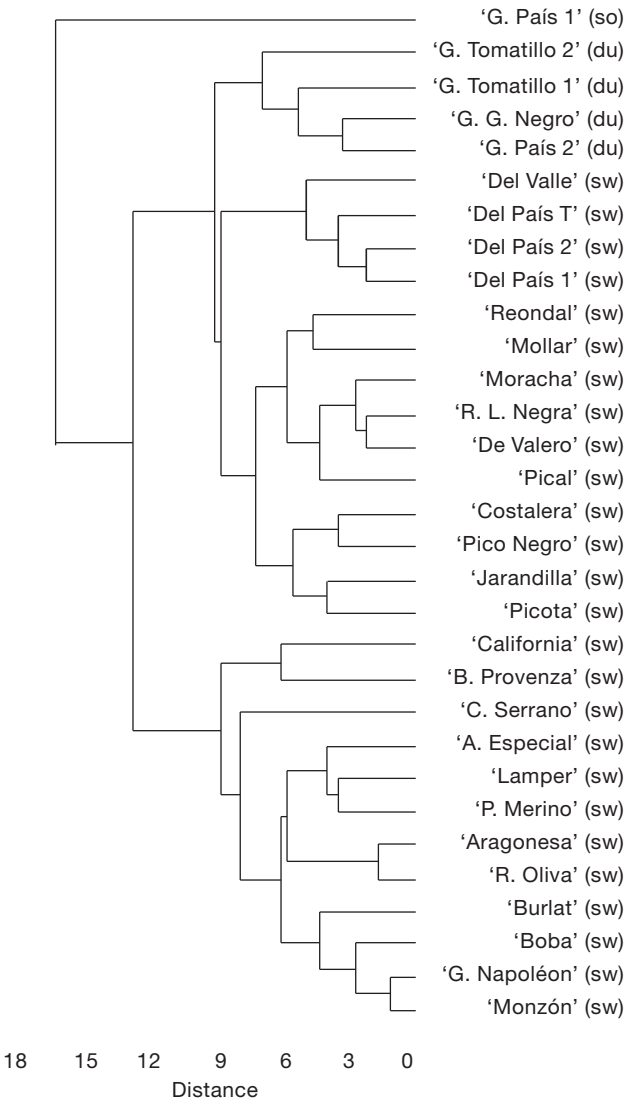

Figure 5. Dendogram produced using the Furthest Neighbour Method (Euclidean) from agromorphological characters of the sweet (sw), sour (so) and duke (du) cherry cultivars in the study.

Conclusions

In conclusion, there were clear differences between local and introduced genetically improved sweet cherry cultivars. Local cultivars had smaller flowers, smaller and sweeter fruits with large endocarps, their appearance was less attractive, they had long peduncles, they were more resistant to cracking, and had saw-toothed leaves that were not spear-shaped but were very pointed with a lower foliar surface area and with long petioles. In addition, many of these cultivars also had drooping habits. Although 'Corazón Serrano' is a local cultivar, it showed great productive potential, thus it could be used in future breeding programs. The cultivars of *P.* × *gondouinii* Rehd. ('Guindo Tomatillo 1', 'Guindo Tomatillo 2', 'Guindo del País 2' and 'Guindo Garrafal Negro') were characterized by not having a drooping habit, and having fruits, flowers and leaves of intermediate size between the sweet and sour cherries and, having nectaries which are slightly reddish in colour and having fruit cracking percentages which were more similar to sweet cherry than to sour cherry. 'Guindo Garrafal Negro' exhibited high cracking resistance.

Thus, in Salamanca province (Spain), 14 local cultivars of *P. avium* L., four of *P.* × *gondouinii* Rehd. and one of *P. cerasus* L. were identified, all of them were clearly regressing or close to disappearance. They were distributed throughout the two main producing areas: Arribes del Duero and Sierra de Francia. Our research

group is currently working to establish a germplasm bank in Salamanca, which will receive these local cultivars to avoid the disappearance of distinctive, unique and interesting agronomic characteristics such as fruit cracking tolerance, a major problem in many cherry producing areas worldwide.

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