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AGRO-MORPHOLOGICAL DIVERSITY OF TRADITIONAL FIG CULTIVARS GROWN IN CENTRAL-WESTERN SPAIN

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There are not many exhaustive works addressing the agromorphological characterization of traditional fig (*Ficus carica* L.) cultivars in Spain. In order to analyze the diversity of these fig genetic resources, twelve traditional fig cultivars from the Central-Western Region of Spain were surveyed and characterized agromorphologically. A total of forty 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 the fruits, leaves and the tree itself over two consecutive years (2013-2014). Some of the cultivars showed distinctive and interesting agronomical characters from a commercial point of view, such as two crops per year (breba and fig), high yields, and fruit quality. This was the case of the fig cultivar widely distributed through the Duero river valley called 'Cuarterón'. Its fruits were quite heavy and sweet (breba: 93.75 g and 25.91º Brix; fig: 42.41 g and 31.50º Brix), easy to peel, and juicy. Principal component analysis revealed that more than 67% of the agromorphological variability observed was explained by the first three components, some of the breba size parameters (fruit and neck length and fruit width) being the most important factors in differentiating the genotypes. A dendrogram clustered the cultivars into two major groups (unifera and bifera type) and revealed existing synonymies and homonymies. 'Carballar Negra' and 'Moscatel' were the only fig cultivars which did not have breba crops. This work is an important step in the conservation of genetic fig resources in Spain.

Keywords: Ficus carica, fig descriptors, conservation, endangered cultivars.

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INTRODUCTION

The common fig (*Ficus carica* L., 2n=26) is a deciduous tree that originated in Western Asia and from there slowly spread throughout the Mediterranean region (TOUS and FERGUSON, 1996). It is a gynodioecious woody perennial species with bisexual trees (functional male caprifigs and unisexual female trees) that is cultured for its edible fruit (STOREY *et al.*, 1977). Its fruits are used for fresh and dried consumption and to produce jam, cake, chocolate, marmalade, and several types of beverages. Three different types of female figs can be distinguished, depending on the cropping/pollination characteristics, namely the common type, Smyrna, and San Pedro (STOVER *et al.*, 2007). Most fig genotypes are the common type, which produces parthenocarpic fruit without pollination; common-type figs are able to produce one (unifera types) or two crops (bifera types) (GIRALDO *et al.*, 2010).

By 2011, world fig production was 1.09 million metric tons (FAOSTAT, 2011). Turkey, Egypt, Algeria, Morocco, Iran, Syria, the United States, and Spain are the most important fig-producing countries (approximately 77% of the world's fig production). In particular, Spain (the first European producer) has 11,761 ha dedicated to fig production and produces 28,993 metric tons of fruit per year. The main fig fruit-producing areas in Spain are Extremadura-Andalusia and neighbouring regions (54%), the Levantine area (26%), and Galicia (14%). In these regions, all the fig fruits (fresh/dry consumption and industrial use) are harvested by hand at the firm-mature stage from May to October. Some of the most common cultivars cultured in Spain are 'De Rey', 'Lampaga', 'Moscatel Negra', 'Napolitana Negra', 'Negra Cabezuela', 'Picholetera', 'San Antonio', 'Albacor', 'Calabacita' and 'Cuello Dama Blanco' (LÓPEZ-CORRALES and BALAS, 2014). Almost all cultivars grown are the result of previous selection and are maintained by vegetative propagation (MARS, 2003). This germplasm is therefore subject to problems of homonymy and synonymy. In addition, an important degree of genetic erosion is currently taking place as result of biotic and abiotic processes (urbanization, the expansion of intensive crops, the absence of caprification, water deficits in marginal areas, etc.) (SALHI-HANNACHI *et al.*, 2004; GIRALDO *et al.*, 2010).

A first step in preventing the disappearance of this genetic material is to carry out exhaustive studies aimed at surveying, characterizing and identifying the existing cultivars in order to subsequently introduce them into any of the two main fig genebanks established in Spain: "Finca La Orden-Valdesequera" (Badajoz, Extremadura) and "Campo Experimental de Son Mut Nou" (Mallorca, Balearic islands).

Many works addressing the agromorphological characterization of fig cultivars have been reported in countries mainly located around the Eastern Mediterranean region (MARS *et al.*, 1998; PAPADOPOULOU *et al.*, 2002; HEDFI *et al.*, 2003; OUKABLI *et al.*, 2003; CHATTI *et al.*, 2004; KOYUNCU, 2004; SADDOUD *et al.*, 2008, 2011; ALJANE and FERCHICHI, 2009; CRISOSTO *et al.*, 2010; DARJAZI, 2011; BEN ABDELKRIM *et al.*, 2012; GOZLEKCI, 2011; ALJANE *et al.*, 2012; ÇALIŞKAN and POLAT, 2012; GAALICHE *et al.*, 2012; BASHEER-SALIMIA *et al.*, 2013; TRAD *et al.*, 2013; KHADIVI-KHUB and ANJAM, 2014; ABBASI and ARJI, 2014). In Spain, some studies have been carried out by SÁNCHEZ *et al.* (2003), LÓPEZ and GUZMÁN (2007), GIRALDO *et al.* (2008; 2010), LÓPEZ-CORRALES *et al.* (2011) and GONZÁLEZ and GRAJAL (2012).

The objective of the present study was to survey, identify and characterize the traditional fig cultivars existing in the Central-West Region of Spain for their introduction into a germplasm bank.

MATERIALS AND METHODS

Plant material

A survey was carried out in the "Arribes del Duero" region (Salamanca province, Spain) during the growing season of 2012. This area constitutes the northern part of the main fig-producing region in Spain at 41º10´50´´N latitude, 6º72´34´´W longitude and 592 m above sea level. This region has an annual average temperature of 14 ºC and an annual precipitation of 667 mm. A total of 96 trees at least 10 years old and corresponding to twelve cultivars ('Antigua', 'Blanca Común', 'Carballar Blanca', 'Carballar Negra', 'Cuarterón', 'Cuello de Dama Blanco', 'Cuello de Dama Negro', 'Gota de Miel', 'Moscatel', 'Prieto', 'Pringo de Mel' and 'Tardía Portuguesa') were selected for study at full fruit maturity. Eight trees were evaluated per cultivar.

Descriptors analysed

The agromorphological characterization of fig cultivars was carried out using 40 descriptors as a basis, mainly established by IPGRI and CIHEAM (2003) and UPOV (2010). For the determination of some of the descriptors, samples of fruits and leaves were taken during the 2013 and 2014 growing seasons.

Thirty fruits were collected randomly at maturity (June-July and September for breba and fig, respectively) from each of the eight trees studied per cultivar and year, and a series of quantitative and qualitative descriptors were recorded. Stalk length (STL), fruit length (FRL), neck length (NEL), fruit width (FRW) and ostiole width (OSW) were measured with a digital caliper with an accuracy of 0.01 mm (DIN-862, Acha, Spain). The elongation or flattening of the fruits was calculated using the fruit length/fruit width ratio. Fruit weight (FWG) was measured with an electronic balance with a precision of 0.001 g (BP 110S, Sartorius, Germany). Total soluble solids (TSS) in each fruit were determined with a digital refractometer (Atago PR-101, Atago Co. Ltd., Japan) at 20°C. The qualitative parameters observed were fruit shape (FRS), fruit skin ground color (FSC), pulp internal color (PIC), fruit juiciness (FJC) and ease of peeling (EPL).

Leaves were collected from the middle part of branches of 1-year-old-shoots after fruit harvesting. In each of the eight trees studied per cultivar, twenty leaves were sampled per year and the following quantitative parameters were measured using a digital caliper with an accuracy of ± 0.01 mm: leaf length (LLG), length of leaf stalk (LLS), width of leaf stalk (WLS), leaf blade length (LBL), leaf blade width (LBW) and length of central lobe (LCL). In the case of the leaves, only one ratio -length of leaf stalk / leaf blade length- was calculated. Five qualitative descriptors were also determined, namely the number of lobes (NLB), the shape of central lobe (SCL), the shape of the leaf base (SLB), the basal lateral lobes on the petiole sinus (LPS) and petiole color (PTC).

Regarding whole trees, the vegetative habit (VHT) and vigor (VIG) of the different cultivars were recorded during the dormant period.

Statistical analyses

For the 12 traditional Spanish fig cultivars, means and standard deviations were calculated for each of the quantitative parameters studied over the 2 years. The unit of measurement of each of the parameters studied was based on the individual value of each of the eight trees sampled per cultivar. Based on all the parameters studied a principal component analysis (PCA) was also carried out using the SPSS 17.0 program, and a dendrogram of genetic

similarities among cultivars was compiled using the Furthest Neighbour Method (Statgraphics Plus 5.0 program).

RESULTS AND DISCUSSION

Agromorphological analysis

Ten of the fig cultivars studied were of the bifera type; they had two crops per year (brebas and figs, respectively). (Tables 1-2). 'Carballar Negra' and 'Moscatel' were the only exceptions. Their brebas could not be harvested because they were lost during development. In this sense, LÓPEZ-CORRALES *et al.* (2011) also indicated that most Spanish fig cultivars are parthenocarpic (unifera or bifera type).

Table 1a. Fruit parameters (main crop) in traditional Spanish fig cultivars, including standard deviation.

Cultivar	STL (cm)	FRL (cm)	NEL (cm)	FRW (cm)	FRL / FRW	OSW (cm)	FWG (g)	TSS (ºBrix)
Antigua	0.64±0.35	4.22±0.43	0.59±0.26	4.20±0.20	1.00±0.06	0.53±0.04	35.20±4.15	19.50±4.31
Blanca Común	1.09±0.42	3.87±0.64	0.28±0.13	3.51±0.44	1.11±0.17	0.45±0.09	17.10±5.07	21.14±6.82
Carballar Blanca	0.85±0.36	4.40±0.64	0.37±0.10	3.51±0.22	1.29±0.18	0.55±0.05	26.29±3.77	32.03±3.26
Carballar Negra	0.33±0.18	4.60±0.71	0.80±0.28	3.23±0.04	1.43±0.21	0.45±0.07	18.00±2.83	32.34±3.64
Cuarterón	0.74±0.33	5.45±1.18	0.71±0.58	4.75±0.76	1.15±0.21	0.55±0.11	42.41±11.85	31.50±0.71
Cuello de Dama Blanco	0.52±0.22	4.36±0.65	0.75±0.18	3.58±0.36	1.26±0.14	0.57±0.08	25.98±9.71	26.13±2.98
Cuello de Dama Negro	0.51±0.30	4.20±0.43	0.69±0.24	3.24±0.30	1.31±0.19	0.43±0.09	24.87±3.21	26.40±1.96
Gota de Miel	0.54±0.19	4.51±0.53	0.78±0.21	3.69±0.41	1.28±0.20	0.59±0.11	27.43±8.02	25.87±3.04
Moscatel	0.41±0.26	3.80±0.22	0.14±0.67	5.70±0.21	0.67±0.16	0.92±0.08	48.62±7.64	22.39±2.64
Prieto	0.77±0.36	3.91±0.57	0.30±0.09	3.80±0.38	1.04±0.21	0.67±0.17	22.33±5.99	17.25±2.47
Pringo de Mel	0.53±0.21	4.45±0.61	0.77±0.29	3.66±0.52	1.27±0.17	0.58±0.14	26.41±10.77	26.38±3.90
Tardía Portuguesa	1.18±0.25	3.25±0.54	0.41±0.12	2.60±0.23	1.25±0.15	0.35±0.06	11.86±2.31	16.23±2.74

Regarding the figs, important differences were recorded among cultivars. Stalk length ranged from 0.33 to 1.18 cm, 'Carballar Negra' and 'Tardía Portuguesa' respectively having the shortest and longest stalks. Similar stalk-length variations (0.12-1.12 cm) were recorded by GONZÁLEZ and GRAJAL (2012) for fig cultivars from the Canary Islands (Spain). All genotypes showed syconia that were longer than wide, except those from the 'Moscatel' cultivar, which had the lowest fruit length/fruit width ratio (0.67). This latter cultivar also had the shortest neck length (0.14 cm) and the greatest ostiole width (0.92 cm). The fruit weight parameter showed considerable variability, 'Antigua', 'Cuarterón' and 'Moscatel' being the cultivars with the heaviest figs (35.20, 42.41 and 48.62 g, respectively). This contrasts with the 'Tardía Portuguesa' cultivar, with fruits of 11.86 g. It is important to note that weight is the most important fruit dimension, and fruit prices depend on this. 'Tardía Portuguesa' also had the lowest soluble-solid levels (16.23º Brix). Three interesting fig cultivars with respect to total soluble solids were

'Cuarterón' (31.50ºBrix), 'Carballar Blanca' (32.03ºBrix) and 'Carballar Negra' (32.34º Brix). The soluble-solid level is related to fruit quality and is a very important parameter for growers to determine the best time to harvest the figs. Other researchers who have recorded important variations in the soluble-solid levels in Spanish fig cultivars were SÁNCHEZ *et al.* (2003). The fruit shape was highly variable among cultivars (Spherical-Urceolate). LÓPEZ and GUZMÁN (2007), LÓPEZ-CORRALES *et al.* (2011) and GONZÁLEZ and GRAJAL (2012) also observed different fruit shapes with Spanish fig cultivars. The most frequent fruit skin ground color was green-yellow ('Antigua', 'Blanca Común', 'Carballar Blanca', 'Cuello de Dama Blanco', 'Gota de Miel', 'Pringo de Mel' and 'Tardía Portuguesa'). By contrast, 'Carballar Negra', 'Cuarterón' and 'Cuello de Dama Negro' were the only cultivars that showed black skin coloration. It is important to remark that skin ground color is the most representative parameter that growers and consumers use to test the quality and optimum stage of maturity in fresh fig fruits; it depends on polyphenolic compounds such as anthocyanins and flavonols. Here, fruit flesh color ranged from white to red. Finally, other interesting cultivars with respect to fruit quality were 'Antigua', 'Cuarterón', 'Cuello de Dama Blanco', 'Gota de Miel' and 'Pringo de Mel'. These developed very juicy and easily peeled fruits.

Table 1b. Fruit parameters (main crop) in traditional Spanish fig cultivars, including standard deviation.

Cultivar	FRS	FSC	PIC	FJC	EPL
Antigua	Spherical	Green-Yellow	Amber-Pink	High	Easy
Blanca Común	Spherical	Green-Yellow	White-Amber	Medium	Medium
Carballar Blanca	Ovoidal	Green-Yellow	Pink	High	Difficult
Carballar Negra	Ovoidal	Purple-Black	Red	High	Difficult
Cuarterón	Turbinate	Purple-Black	Red	High	Easy
Cuello de Dama Blanco	Spherical-Turbinate	Green-Yellow	Amber-Pink	High	Easy
Cuello de Dama Negro	Ovoidal	Black	Pink	Low	Medium
Gota de Miel	Spherical-Turbinate	Green-Yellow	Amber-Pink	High	Easy
Moscatel	Urceolate	Green-Purple	Pink-Red	Medium	Easy-Medium
Prieto	Spherical	Purple	Amber-Pink	Low	Difficult
Pringo de Mel	Spherical-Turbinate	Green-Yellow	Amber-Pink	High	Easy
Tardía Portuguesa	Spherical	Green-Yellow	Pink	Low	Difficult

With respect to breba descriptors, there was remarkable variation among cultivars. 'Carballar Negra' and 'Moscatel' were the only cultivars with one crop per year (unifera type). All the cultivars studied had fruit-stalk lengths of less than 0.76 cm, except for 'Blanca Común' (1.05 cm), and syconia that were longer than wide (mean fruit length/fruit width ratio: 1.33). Important neck lengths were recorded in all cases, ranging between 1.34 and 2.03 cm. The breba weight parameter varied considerably among cultivars. 'Cuarteron', 'Gota de Miel', 'Pringo de Mel' and 'Cuello de Dama Blanco' were the cultivars with the heaviest fruits (93.75, 92.99, 92.55 and 91.15 g, respectively). At the other extreme were 'Prieto' (40.23 g) and 'Tardía Portuguesa' (42.05 g). This latter cultivar gave low yields in both fig and breba production. Total soluble solids ranged from 13.76 to 25.91ºBrix, 'Cuarterón', 'Cuello de Dama Blanco', 'Gota de Miel' and 'Pringo de Mel' being the cultivars with the highest TSS levels. LÓPEZ-CORRALES *et al.* (2011) also indicated

that 'Cuello de Dama Blanco' has a very sweet first crop. The brebas were generally sweeter than figs (mean soluble solids: 20.84 and 24.76ºBrix, respectively). These results agree with those obtained by ÇALIŞKAN and POLAT (2012): 15.4 and 21º Brix in breba and fig crops, respectively.

Table 2a. Fruit parameters (first crop) in traditional Spanish fig cultivars, including standard deviation.

Cultivar	STL (cm)	FRL (cm)	NEL (cm)	FRW (cm)	FRL / FRW	OSW (cm)	FWG (g)	TSS (ºBrix)
Antigua	0.56±0.08	7.55±0.21	1.58±0.17	5.75±0.21	1.31±0.08	0.90±0.17	88.85±6.94	16.88±2.67
Blanca Común	1.05±0.17	6.05±0.25	1.34±0.21	4.80±0.29	1.26±0.11	0.51±0.15	48.74±4.98	17.83±1.82
Carballar Blanca	0.47±0.08	6.60±0.34	1.81±0.14	5.05±0.26	1.31±0.15	0.60±0.11	51.59±6.37	24.18±2.88
Carballar Negra	No breba production							
Cuarterón	0.48±0.05	8.45±0.57	2.03±0.27	6.11±0.37	1.38±0.14	0.86±0.13	93.75±13.43	25.91±3.82
Cuello de Dama Blanco	0.50±0.07	7.71±0.20	1.58±0.15	5.75±0.18	1.33±0.08	0.59±0.14	91.15±4.14	25.03±2.31
Cuello de Dama Negro	0.46±0.10	8.24±0.38	1.55±0.19	5.51±0.17	1.46±0.09	0.51±0.10	90.09±5.16	18.01±2.20
Gota de Miel	0.53±0.09	7.92±0.29	1.61±0.21	5.93±0.21	1.34±0.10	0.61±0.12	92.99±5.02	24.74±2.19
Moscatel	No breba production							
Prieto	0.76±0.07	5.75±0.22	1.42±0.19	4.92±0.15	1.17±0.09	0.61±0.16	40.23±5.81	13.76±2.81
Pringo de Mel	0.51±0.11	7.85±0.33	1.60±0.18	5.88±0.26	1.34±0.06	0.60±0.14	92.55±4.82	24.19±1.97
Tardía Portuguesa	0.52±0.08	6.31±0.27	1.48±0.14	4.42±0.11	1.43±0.09	0.69±0.12	42.05±2.37	17.91±2.71

Table 2b. Fruit parameters (first crop) in traditional Spanish fig cultivars, including standard deviation.

Cultivar	FRS	FSC	PIC	FJC	EPL
Antigua	Turbinate	Green-Yellow	Amber-Pink	High	Easy
Blanca Común	Turbinate	Green-Yellow	Amber	Medium	Medium
Carballar Blanca	Turbinate	Green-Yellow	Pink-Red	High	Difficult
Carballar Negra	No breba production				
Cuarterón	Turbinate	Purple-Black	Red	High	Easy
Cuello de Dama Blanco	Spherical- Turbinate	Green-Yellow	Amber-Pink	High	Easy
Cuello de Dama Negro	Pyriform	Black	Pink	Low	Medium
Gota de Miel	Spherical- Turbinate	Green-Yellow	Amber-Pink	High	Easy
Moscatel	No breba production				
Prieto	Turbinate	Purple	Amber-Pink	Low	Difficult
Pringo de Mel	Spherical- Turbinate	Green-Yellow	Amber-Pink	High	Easy
Tardía Portuguesa	Turbinate	Green-Yellow	Amber	High	Easy

With respect to qualitative breba parameters, important differences were observed among cultivars. The most frequent fruit shapes were turbinate or spherical-turbinate. 'Cuello de Dama Negro' was the only cultivar that showed pyriform fruits. LÓPEZ-CORRALES *et al.* (2011) also

observed that this cultivar has pyriform breba. The fruit skin ground color was generally green-yellow, 'Prieto' (purple), 'Cuarterón' (purple-black) and 'Cuello de Dama Negro' (black) being the only exceptions. Fruit flesh color ranged from amber to red. Finally, some relevant cultivars with regard to breba quality were 'Antigua', 'Cuarterón', 'Cuello de Dama Blanco', 'Gota de Miel', 'Pringo de Mel' and 'Tardía Portuguesa'. Their fruits were very juicy and easily peeled.

Leaf parameters are summarized in Table 3. Leaf length varied from 24.78 to 36.30 cm, 'Tardía Portuguesa' being the cultivar with the longest leaf. Its blade size was also large, with a length of 29.46 cm and a width of 24.28 cm. Stalk length ranged from 4.89 ('Moscatel') to 13.37 cm ('Carballar Negra'). It was observed that the leaf blades were longer than the stalks in all the fig cultivars (stalk length /blade length ratio: 0.22-0.65). With respect to the number of main lobes, most cultivars showed three/five-lobed leaves. These results are consistent with those reported by LÓPEZ and GUZMÁN (2007) and GONZÁLEZ and GRAJAL (2012) for Spanish fig cultivars. 'Carballar Blanca', 'Cuarterón' and 'Moscatel' were the only cultivars that showed entire leaves. The shape of central lobe varied between triangular ('Carballar Blanca' and 'Cuarterón') and lyrate ('Cuello de Dama Negro'). LÓPEZ-CORRALES *et al.* (2011) also observed a lyrate central lobe shape in leaves of this latter cultivar. The shape of the leaf base was highly variable among cultivars (truncate-strongly calcarate). Regarding the basal lateral lobes on the petiole sinus, most cultivars did not have additional lobes. They were only observed in the leaves of the 'Blanca Común', 'Carballar Negra' and 'Cuello de Dama Negro' cultivars. The most frequent petiole color was green.

Table 3a. Leaf parameters in traditional Spanish fig cultivars, including standard deviation

Cultivar	LLG (cm)	LLS (cm)	WLS (cm)	LBL (cm)	LBW (cm)	LCL (cm)	LLS/ LBL
Antigua	24.78±2.59	8.21±1.46	0.46±0.04	16.57±1.97	15.02±1.87	10.47±1.10	0.50±0.10
Blanca Común	26.60±4.46	10.16±2.13	0.45±0.11	16.18±2.55	15.82±3.05	10.36±1.98	0.65±0.11
Carballar Blanca	28.96±2.98	10.76±1.64	0.55±0.06	18.28±2.37	20.04±2.30	12.22±1.24	0.59±0.09
Carballar Negra	36.10±2.74	13.37±1.43	0.50±0.05	23.01±1.85	21.58±2.05	14.27±1.59	0.58±0.10
Cuarterón	27.64±3.79	8.70±1.73	0.61±0.10	18.94±2.47	17.09±2.15	9.20±1.07	0.47±0.09
Cuello de Dama Blanco	27.42±2.03	9.17±1.56	0.48±0.05	18.05±1.97	17.34±2.43	10.41±1.11	0.50±0.09
Cuello de Dama Negro	26.71±2.63	9.01±1.40	0.46±0.05	17.71±1.98	16.92±2.01	13.02±2.14	0.51±0.08
Gota de Miel	27.05±2.28	9.33±1.94	0.49±0.07	18.53±2.01	17.81±2.21	10.52±1.47	0.51±0.10
Moscatel	27.25±2.08	4.89±2.34	0.55±0.06	22.36±2.64	23.64±3.14	12.49±2.64	0.22±0.07
Prieto	27.92±3.04	9.30±1.59	0.26±0.04	18.62±2.07	15.65±1.50	10.67±2.32	0.50±0.08
Pringo de Mel	27.57±2.96	9.21±1.88	0.49±0.08	18.36±1.72	17.47±2.12	10.63±1.63	0.51±0.11
Tardía Portuguesa	36.30±2.81	10.73±1.82	0.70±0.05	29.46±1.94	24.28±2.09	14.66±1.28	0.36±0.08

Table 3b. Leaf parameters in traditional Spanish fig cultivars, including standard deviation

Cultivar	NLB	SCL	SLB	LPS	PTC
Antigua	Three-lobed / Five-lobed	Rhombic	Cordate - Strongly calcarate	Absent	Green
Blanca Común	Three-lobed / Five-lobed	Linear	Cordate- Strongly calcarate	Present	Light green
Carballar Blanca	Entire / Three-lobed	Triangular	Cordate- Strongly calcarate	Absent	Light green
Carballar Negra	Three-lobed / Five-lobed	Rhombic	Cordate	Present	Green
Cuarterón	Entire / Three-lobed	Triangular	Cordate	Absent	Green
Cuello de Dama Blanco	Three-lobed / Five-lobed	Rhombic	Cordate	Absent	Green
Cuello de Dama Negro	Three-lobed / Five-lobed	Lyrate	Calcarate	Present	Green
Gota de Miel	Three-lobed / Five-lobed	Rhombic	Cordate	Absent	Green
Moscatel	Entire / Three-lobed / Five-lobed	Rhombic	Truncate-Cordate	Absent	Green
Prieto	Three-lobed / Five-lobed	Rhombic	Truncate- Cordate	Absent	Green
Pringo de Mel	Three-lobed / Five-lobed	Rhombic	Cordate	Absent	Green
Tardía Portuguesa	Three-lobed / Five-lobed	Spatulate	Cordate- Strongly calcarate	Absent	Green

Tree descriptors are shown in Table 4. Very diverse vegetative habits were observed, ranging from semierect to weeping. LÓPEZ-CORRALES *et al.* (2011) also observed considerable variability in the growth habit character of Spanish fig cultivars. Vigor ranged between weak (‘Carballar Blanca’) and strong (‘Antigua’, ‘Blanca Común’ and ‘Prieto’).

Table 4. Tree parameters in traditional Spanish fig cultivars

Cultivar	VHT	VIG
Antigua	Spreading-Weeping	Strong
Blanca Común	Open- Spreading	Strong
Carballar Blanca	Semierect-Open	Weak
Carballar Negra	Semierect	Medium
Cuarterón	Open- Spreading	Medium
Cuello de Dama Blanco	Semierect-Open	Medium
Cuello de Dama Negro	Semierect	Medium
Gota de Miel	Semierect-Open	Medium
Moscatel	Spreading - Weeping	Medium
Prieto	Spreading - Weeping	Strong
Pringo de Mel	Semierect-Open	Medium
Tardía Portuguesa	Semierect-Open	Medium

Upon analysing the results concerning agromorphological characterization, important similarities were observed among some fig cultivars. This was the case of ‘Cuello de Dama

Blanco', 'Gota de Miel' and 'Pringo de Mel'. Their fruits, leaves and the trees themselves showed great similarity.

Statistical analyses

Principal component analysis (PCA) was used to identify the traits with the highest variation between cultivars and the greatest impact on their separation in the data set (IEZZONI and PRITTS, 1991). The PCA results based on leaf, fruit and tree traits revealed that more than 67% of the variability observed was explained by the first three components (PC1-PC3) (Table 54). These findings are in agreement with those obtained by CHATTI *et al.* (2004), ALJANE and FERCHICHI (2009) and ABBASI and ARJI (2014) for fig cultivars in the Mediterranean area; based on morphological traits, PCA revealed that the first 3 components explained comparable values (from 61% to 71%) of the total variation. The first component (PC1), accounting for 33.5% of the total variance, was strongly influenced by breba size parameters, such as fruit and neck length and fruit width. The second component (PC2) accounted for 18.8% of the total variation and was mainly explained by fruit and ostiole width, fruit weight and ease of peeling (fig traits) and leaf size parameters, such as leaf length and length of leaf stalk and the central lobe. Finally, the third principal component (PC3), explaining 14.8% of the total variation, was formed by the tree traits (vegetative habit and vigor) and different descriptors related to the fig (fruit and neck length, fruit length/fruit width ratio, total soluble solids and fruit juiciness). Other researchers who have suggested that fruit and leaf traits are important factors in differentiating and analyzing breeding materials, addressing the morphological characterization of fig cultivars, are MARS *et al.* (1998), HEDFI *et al.* (2003), SADDOUD *et al.* (2008, 2011), GAALICHE *et al.* (2012), ALJANE *et al.* (2012) and KHADIVI-KHUB and ANJAM (2014).

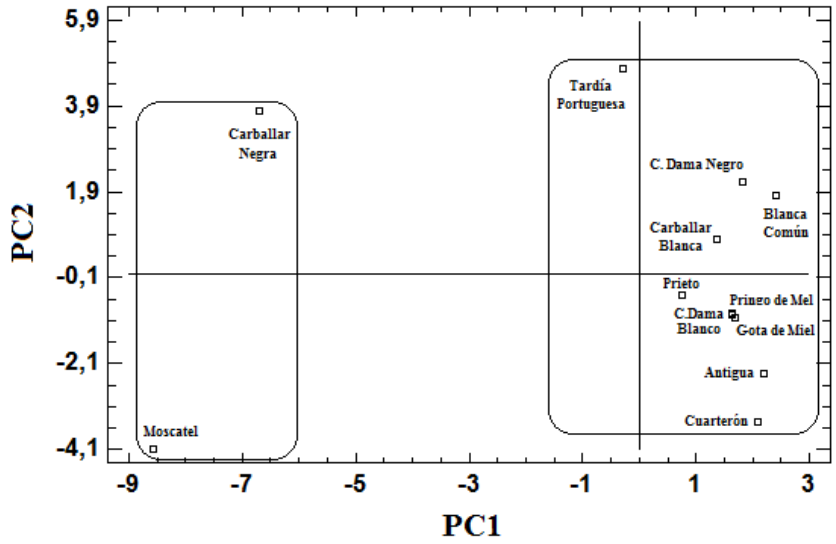

Figure 1. Scatter plot of the first two principal components (PCs) for the 12 traditional Spanish fig cultivars based on agromorphological characters.

Figure 1 shows a scatter-plot of the first two principal components (PCs) for the 12 traditional Spanish fig cultivars based on agromorphological characters. It can be observed that there are two main groups of cultivars. The first group included 'Carballar Negra' and 'Moscatel' (unifera type) and the second one contained the rest of cultivars analyzed (bifera type). GIRALDO *et al.* (2010) also clearly separated unifera and bifera cultivars by PCA analysis based on morphological traits.

Table 5. Eigenvalues and results of the first 3 principle component (PC) analyses of the agromorphological characteristics in traditional Spanish fig cultivars.

Principal components	PC1	PC2	PC3
Eigenvalue	13.38	7.52	5.92
Variance (%)	33.47	18.80	14.81
Cumulative variance (%)	33.47	52.27	67.08

	Descriptors	PC1	PC2	PC3		Descriptors	PC1	PC2	PC3
Fruit -Fig-	Stalk length	0.24	0.26	0.32	Fruit -Breba-	Stalk length	0.44	0.06	0.38
	Fruit length	0.10	-0.30	**-0.60**		Fruit length	**0.52**	-0.06	-0.08
	Neck length	0.14	0.04	**-0.60**		Neck length	**0.50**	-0.06	-0.10
	Fruit width	-0.20	**-0.64**	0.06		Fruit width	**0.52**	-0.08	-0.04
	Fruit length/fruit width	0.18	0.46	**-0.50**		Fruit length/fruit width	**0.52**	0.04	0.00
	Ostiole width	-0.24	**-0.56**	0.16		Ostiole width	0.48	-0.10	0.00
	Fruit weight	-0.12	**-0.66**	-0.10		Fruit weight	0.46	-0.20	-0.22
	Total soluble solids	-0.04	-0.04	**-0.72**		Total soluble solids	0.48	-0.08	-0.22
	Fruit shape	-0.36	-0.14	-0.30		Fruit shape	0.42	0.14	0.12
	Fruit skin ground color	-0.18	0.00	-0.10		Fruit skin ground color	0.36	-0.04	0.02
	Pulp internal color	-0.30	-0.04	-0.48		Pulp internal color	0.48	-0.10	-0.18
	Fruit juiciness	0.02	-0.28	**-0.54**		Fruit juiciness	0.40	-0.08	-0.20
	Ease of peeling	-0.14	**0.52**	0.16		Ease of peeling	0.32	0.10	0.24
Leaf	Leaf length	-0.24	**0.52**	-0.18		Length of leaf stalk/leaf blade length	0.28	0.26	-0.16
	Length of leaf stalk	0.06	**0.58**	-0.28		Number of lobes	0.02	0.28	0.34
	Width of leaf stalk	-0.08	0.10	-0.36		Shape of central lobe	0.06	0.36	0.34
	Leaf blade length	-0.28	0.32	0.00		Shape of leaf base	0.26	0.36	-0.08
	Leaf blade width	-0.38	0.22	-0.12		Basal lateral lobes on petiole sinus	-0.06	0.40	0.02
	Length of central lobe	-0.30	**0.50**	-0.02		Petiole color	-0.12	-0.16	-0.10
Tree	Vegetative habit	-0.06	-0.44	**0.52**		Vigor	0.08	-0.06	**0.58**

Eigenvalues ≥ 0.50 are significant

Figure 2 shows a dendrogram of the relationships among the fig cultivars obtained upon analyzing all the parameters studied. The dendrogram also clusters the cultivars into two major groups (unifera and bifera type). On analysing the dendrogram, a series of synonymies among the fig trees can also be seen. Such is the case of 'Cuello de Dama Blanco', 'Gota de Miel' and 'Pringo de Mel'. Significant similarities were observed among these latter three cultivars for all agromorphological traits. By contrast, a homonym was also detected: 'Cuello de Dama Negro' and 'Cuarterón'. Despite their major agromorphological differences, both names are often used interchangeably by some growers.

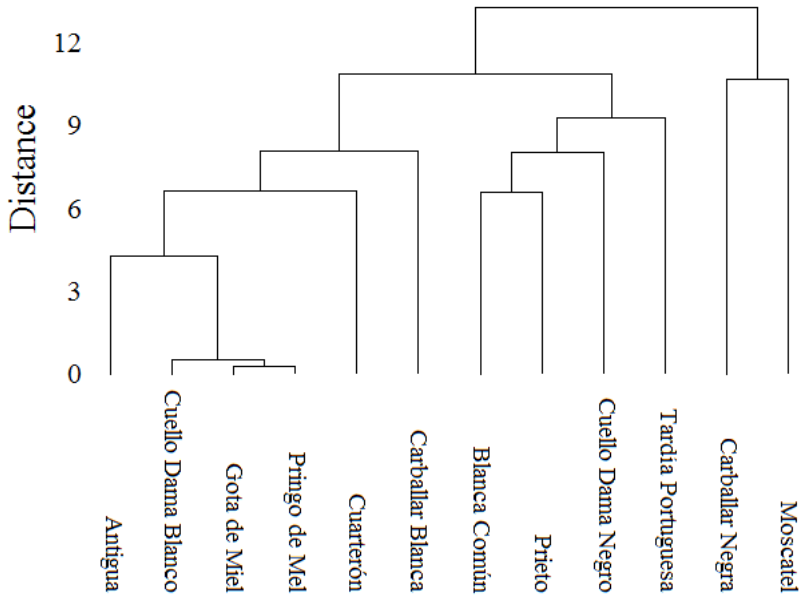

Figure 2. Dendrogram produced using the Furthest Neighbour Method (Euclidean) from the agromorphological characters of traditional Spanish fig cultivars.

CONCLUSIONS

Twelve traditional fig cultivars from "Arribes del Duero" in Central-West Region of Spain were surveyed and characterized agromorphologically. Some of the cultivars showed distinctive and interesting agronomical characters from a commercial point of view, such as two crops per year (breba and fig), high yields, and fruit quality. This was the case of the fig cultivar called 'Cuarterón'. Its fruits were quite heavy and sweet (breba: 93.75 g and 25.91º Brix; fig: 42.41 g and 31.50º Brix), easy to peel and juicy. 'Carballar Negra' and 'Moscatel' were the only fig cultivars that did not give breba crops. Many agromorphological descriptors are highly useful parameters to characterize, evaluate and differentiate fig genotypes. This work constitutes an important step in the conservation of genetic fig resources in Spain.

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AGROMORFOLOŠKI DIVERZITET KULTIVARA TRADICIONALNOG FIKUSA (*Ficus carica* L.) GAJENOG U ZAPADNOJ ŠPANIJI

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Izvod

Vršena je agromorfološka karakterizacija dverziteta 12 tradicionalnih kultivara kao genetičkih resursa fikusa gajenih u centrealno - zapadnom region Španije. Korišćeno je ukupno 40 deskriptora definisanih u Međunarodnom Institutu za Biljne Genetičke Resurse i Međunarodnoj Uniji za Zaštitu Biljnih Sorata. Deascriptori su korišćeni za opis plodova, listova i stabala dve uzastopne godine (2013 i 2014). Nneki od ispitivanih kultivara su pokazali različite i interesantne agronomske osobine kao dve berbe godišnje, visok prinos i visok kvalitet plodova. Analizom principijelnih komponenata je potvrđeno da više od 67 % agromorfološke varijabilnosti može da se objasni sa prve tri komponente (dužina plod i vrata ploda i širina ploda) koje su najvažniji faktori u diferenciranju genotipova. Dendogrami su grupisali kultivare u dve glavne grupe (unifera i bifera tip) što je potvrdlo postojanje sinonia i homonima. 'Carballar Negra' o'Moscatel' su jedini kultivari koji nisu imali breb plod. Dobijeni rezultati su doprinos konzervaciji genetičkih resursa fikusa u Španiji.

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