A core collection of common bean from the Iberian peninsula

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Summary

Characterization of crop germplasm from specific regions helps understand the patterns of genetic variation that facilitates further germplasm collection, characterization, management and their more efficient utilization in genetics, breeding and other studies. Common bean (*Phaseolus vulgaris* L.) is a traditional crop in the Iberian Peninsula (Spain and Portugal) where subsistence farmers have been growing and maintaining their own cultivars since their introductions from the Americas in the sixteenth century. Our objectives were to: (i) characterize diversity in the landraces collected from the Iberian Peninsula and (ii) form a core collection. Of 388 landraces from the major production regions characterized for 34 quantitative and 13 qualitative characters, including morphological, agronomic and biochemical traits, 74.7% had an Andean origin, 16.8% a Mesoamerican origin and 8.4% had seed mixtures or were recombinants between the two gene pools. Landraces of indeterminate climbing growth habit Type IV (47.2%) and bush determinate Type I (26.4%) with large (52.9%) and medium (27.4%) seeds of white (38.8%) and cream (25.9%) colour were predominant. Similarly, the "T" phaseolin pattern and common bean race Nueva Granada were the most frequent (51%). Some exceptionally large-seeded landraces of Andean (e.g., PHA-0917 with 119 g 100-seed weight^{-1}) and Mesoamerican (e.g., PHA-0399 with 66 g 100-

seed weight^{-1}) were found. These and other possible recombinants between the two gene pools merit further investigation. Fifty two landraces (13 %) were chosen to form a core collection representing the genetic diversity in the Iberian Peninsula.

Introduction

Common bean (*Phaseolus vulgaris* L.), domesticated in Mesoamerica and Andean South America (Gepts et al., 1986), was introduced into Spain after the colonization of the Americas. The two major Andean and Mesoamerican gene pools have been identified based on morphological and agronomical traits (Singh et al., 1991b), phaseolin seed protein (Koenig et al., 1990), isozymes (Koenig & Gepts, 1989; Singh et al., 1991c), molecular markers (Becerra-Velásquez & Gepts, 1994; Freyre et al., 1996; Haley et al., 1994) and adaptation traits (Singh, 1989; Voysest & Dessert, 1991). Generally, Mesoamerican germplasm are either small- (<25 g 100 seed-weight^{-1}) or medium-seeded (25 to 40 g 100-seed weight^{-1}) with phaseolin patterns "S" and "B" types, different from those of their large-seeded (>40 g 100 seed-weight^{-1}) Andean counterparts with "T", "C", "H" and "A" phaseolin types (Gepts et al., 1986; Singh et al., 1991a). Cultivars within the two gene pools have been divided into six races: Mesoamerica, Durango and Jalisco of Mesoamerican origin; and Chile, Peru and Nueva Granada of Andean origin (Singh et al., 1991a).

Although there is a lack of knowledge about bean germplasm dissemination, Gepts & Bliss (1988) and Gepts & Debouck (1991) suggested that the European germplasm was primarily from the Andes. However, it is probable that the initial common bean accessions introduced in Europe were from Mesoamerica, because Columbus arrived in Central America in 1492 and Cortés reached Mexico in 1518. In 1528, Pizarro explored Perú, opening the possibility to introduce common bean accessions from the Andes. Thus, subsequently new cultivars may have evolved within and between the two gene pools in Southern Europe (mainly Spain and Portugal) making this region a secondary center of diversity for the common bean (Santalla et al., 2002). Moreover, seed exchange occurred mainly in the Northwest Spain (Galicia) where bean still is intercropped with maize, similar to the cropping system popular in Latin America (Santalla et al., 1994). Within Europe there was likely a quick distribution of seeds as curiosities (Zeven, 1997). Europeans still collect common beans from neighbouring and faraway regions. No records of common bean earlier than 1543 have been found in NW European herbariums, suggesting that the common bean was distributed in NW Europe after 1540, and in 1669 it was already cultivated on a large scale (Zeven, 1997).

Currently common bean is one the most important legumes for human consumption in Europe and some large germplasm collections are maintained in different countries (Amurrio et al., 2001). Lioi (1989) studied accessions from Italy and Cyprus, as well as from other non-European countries. Limongelli et al. (1996) and Piergiovanni et al. (2000) analysed seed quality of Italian beans, while Casañas et al. (1997) and Mihálikova & Benková (1995) characterized other European germplasm.

Common bean is one of the most widely cultivated grain legumes in the Iberian Peninsula. New cultivars are displacing landraces but farmers still grow landraces for personal-consumption and sale in farmer’s markets. Genetic variability found for seed colour, size (although, in general, large seeded cultivars are preferred), shape and other characters is very high among genotypes grown by farmers in the Northwestern Spain and Northern Portugal (Gil & Ron, 1992; Rodiño et al., 2001). It is therefore still possible to collect valuable germplasm from this region (Ron et al., 1997). The Legumes Breeding Group at the Mision Biologica de Galicia - Spanish Council for Scientific Research (MBG-CSIC) has an Iberian common bean germplasm collection and oversees the task of further collecting, evaluating and maintaining the landraces (Ron et al., 1997).

Knowledge of patterns of genetic diversity among landraces and their relationships with new cultivars helps broaden the genetic base and maximizes use of available germplasm. In spite of increasing use of the DNA-based markers for studying genetic diversity, study of phenotypic variation in a germplasm collection is crucial for determining adaptation, agronomic potential and breeding value of landraces. Gil & Ron (1992) and Escribano et al. (1998) reported variation for morphological, agronomical and biochemical characters in common bean germplasm from NW Iberian Peninsula. Alvarez et al. (1998) estimated variation within and between common bean landraces for isozymes, random amplified polymorphic DNA (RAPD) markers, storage protein and amino acid content. These studies revealed proportionally higher variation in Spanish common bean landraces than in other germplasm previously studied.

Brown (1989) proposed formation and use of a core collection for studying and utilization of genetic diversity in large germplasm collections. Ideally, a core collection should represent most if not all diversity in the entire collection with a minimum or no redundancy (Tohme et al., 1995). With this aim in Europe core collections have been developed in different crops (Bennett et al., 2000; Liu et al., 2000; Polignano et al., 1999; Swiecicki et al., 2000). Our objectives were to: (i) determine patterns of diversity among the common bean landraces from the Iberian Peninsula and (ii) form a core collection.

Materials and methods

Of 388 Iberian Peninsula common bean accessions evaluated (maintained at the MBG-CSIC, Pontevedra, Spain), 286 were landraces or garden forms from Spain and 102 from Portugal. These represented different market classes (Ron et al., 1997; Santalla et al., 2001). The Portuguese landraces have been described by Rodiño et al. (2001).

Landraces were grown in field at Pontevedra (Northwestern Spain, 42 ºN, 8 ºW, altitude 40 m, 14 ºC average temperature and 1600 mm annual rainfall) in 1998 and 1999. The experimental design was a "hill-plot", with 8 plants-plot, spaced 1 x 1 m between plots, thus giving a planting density of 80,000 plants/ha.

The following 34 quantitative characters and indices were determined (IBPGR, 1982; Santalla et al., 1994; Singh et al., 1991b): days to first flower, 50% flowering, end of flowering, flowering duration, fresh pod maturity, and first dry pod; length and width of central trifoliate leaflet (cm) and bracteole (mm); leaflet and bracteole length/width; length, width, thickness and curvature of fresh pod (mm); length/width and width/thickness of fresh pod; weight of five fresh pods (g); number of seeds per pod; number of pods per plant; pod yield (g/plant); seed dimensions (mm) (length, width, thickness, length/width and width/thickness); 100-seed weight (g); crude protein content (%); moisture content (%); crude fat content (%); crude starch content (%); total sugar content (%) (by Near Infrared Transmission spectroscopy using an Infratec 1255 Food and Feed Analyser) and seed yield (g/plant). Thirteen qualitative characters were also determined: growth habit (from I to IV) (Hidalgo, 1991); shape of leaflet (cordate, lanceolate or ovate); leaf hairiness (sparse or dense); flower colour (white, pink or purple); shape of bracteole (cordate, lanceolate or ovate); stripes on the base of flower standard (stripped or smooth); pod fibre (scored on a 1 to 5 scale, where 1 = absence of fibre and 5 = highly fibrous); pod colour (green, yellow or green with purple or yellow strip); pod beak position (placental or central) and curvature (curved or straight); shape of pod (flat or round) and seed shape (kidney, round or oval) and colour (white, cream, yellow, pink, red, brown, purple, black, bicolour) (Schachl & De La Rosa, 2001). Phaseolin protein pattern was analysed for five seeds for each landrace, using one-dimensional sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), according to the method described by Ma & Bliss (1978), Brown et al. (1981) and Gepts et al. (1986) using the reference genotypes for identification of phaseolin patterns.

The core collection was formed according to the hierarchial or branching method described by van Hintum (1995) and van Hintum et al. (2000). In that, the seed phaseolin type, an evolutionary marker (Gepts & Bliss, 1985; Gepts et al., 1986), was initially used to separate accessions into Andean (e.g., ‘T’, ‘C’, ‘H’) and Mesoamerican (e.g., ‘S’, ‘B’) gene pools. Within each gene pool, accessions with the same phaseolin type formed sub-groups. Morphological traits, such as, size and shape of the terminal trifoliolate leaflet, flower bracteoles, and dry seed, the presence or absence of stripes at the outer base of the flower standard, and pod beak position were used to corroborate the Andean versus Mesoamerican gene pool, determine the race affiliations, and identify recombinants or new forms between the two gene pools. The number of accessions selected from each group to form the core collection was proportional to the size of the group and their geographical distribution. Moreover, accessions with unique characteristics (e.g., extremely large seed weight or rare recombinants between gene pools, i.e., small seed with Andean phaseolin or large seed with Mesoamerican phaseolin), despite their extremely low frequency, were included in the core collection. Subsequently, variation for each trait within the core and base collections was compared to assure consistency of genetic variability.

Results and discussion

The mean, standard deviation and range for each of the 34 quantitative characters recorded for 388 common bean accessions (Table 1) indicated greater phenotypic diversity for most characters than that found by Escribano et al. (1998) in the same region. Earliness of pod maturity is an important characteristic because it helps escape or reduce incidence of insect pests and diseases. It permits farmers to bring beans to market when they can obtain high prices. It also may extend planting periods and permit farmers growing a catch crop or double cropping in temperate environments. PHA-0389, PHA-0428, PHA-0561 and PHA-0589 maturated early (< 40 days to beginning of flowering). Because early maturity is often negatively correlated with seed yield in common bean (White & Singh, 1991), these landraces would require further evaluation in replicated trials across contrasting environments for identification of superior genotypes. PHA-0215, PHA-0252, PHA-0296 and PHA-0343 had large pods (> 170 mm long and > 14 mm width), and PHA-0917, PHA-0923, PHA-0926, PHA-0927 and PHA-0928 produced extra-large seeds (> 80 g 100-seed weight^{-1}). PHA-0155, PHA-0262, PHA-0412, PHA-0502 and PHA-0582 produced high yields (> 40 g/plant).

Regarding the nutritional quality of seed two traits could be emphasized: protein content and sugar content, the last one as component of flavour. Landraces PHA-0160, PHA-0228, PHA-0247, PHA-0280, PHA-0388, PHA-0493 and PHA-0556 scored over 30,0 % in protein content while PHA-0309, PHA-0314, PHA-0317 and PHA-0566 had more than 6,0 % sugar content that displays the value of those landraces for breeding of seed quality.

There was a predominance of landraces with indeterminate strong climbing growth habit Type IV (Table 2). This could be largely because these relatively late maturing genotypes permit farmers to take full advantage of long summer growing seasons in the traditional maize-common bean cropping systems as well as in monoculture systems grown with support, thus maximizing yield per unit of cropped land. In the Iberian Peninsula, Andean genotypes with large, white or mottled seeds of different colours and indeterminate growth habit usually are grown in association with maize. These types are preferred by growers and consumers and hence their comparatively high frequency among the 388 accessions studied**.** Accessions with ovate shape central leaflets and short and sparse leaf hairs were predominant. Similarly, accessions with lanceolate flower bracteoles, white colour petals and pods with placental and curved beak were more frequent. Gil & Ron (1992) also recorded very high variability among Spanish common bean landraces for seed colour, size and shape and other qualitative characters.

Because historical and linguistic information provide little evidence regarding the origin and dissemination of common bean in Europe, phaseolin protein pattern, an evolutionary marker (Gepts et al., 1986), was used to complement morphological and agronomic data. This phaseolin protein analysis was useful to identify gene pools and the origin of accessions as to the Middle American or Andean domestication centers. Also, it facilitated identification of subgroups and duplicates. The Andean “T” type phaseolin pattern was present in

36% of accessions, Andean “C” type in 22% and Andean “H” type in 21%. The Mesoamerican “S” and “B” patterns were present in 19% and 2% accessions, respectively. Among 112 accessions from the Iberian Peninsula, Gepts & Bliss (1988) found a high frequency of “C” phaseolin pattern. Lioi (1989) evaluated phaseolin protein patterns of 372 accessions from the Mediterranean (Italy and Cyprus) and other areas. More recently, Ocampo et al. (2002) compared 54 Spanish accessions with the representative wild common bean populations from its domestication range in Latin America, using phaseolin seed protein patterns and RAPD markers. Their results agreed with those of Gepts & Bliss (1988) indicating the highest frequency (57%) of accessions with the Andean “C” phaseolin, followed by “T” type (26%). The Mesoamerican “S” phaseolin was found in 15% accessions. Furthermore, the Andean accessions were domesticated from the wild populations from central and southern Peru, Bolivia and Argentina. In our study and among 66 accessions from the NW Iberian Peninsula studied by Escribano et al.(1998)., the “T” and “H” phaseolin patterns were more frequent than the type “C”. Thus, the current collection of landraces were more diverse than those studied earlier probably due to the fact that bean growers and gardeners in Iberian Peninsula were regularly experimenting and introducing new bean types during the past 500 years. Such new bean types may have derived from periodic introductions from the Americas and hybridisation and mutations (Zeven, 1997).

Comparatively, high frequency (79%) of accessions with “T”, “C” and “H” phaseolin patterns observed in Iberian Peninsula may indicate that genotypes originating in the Andes were better adapted to the cool and short summer of

Western Europe compared to the Middle American cultivars. Their high frequency may also be due to generally greater preference for larger beans in the Iberian Peninsula and Europe because people preferred eating large-seeded fabas. Alternatively, high frequency of the Andean common beans may be due to higher proportion of cultivars grown for harvests of their green pods (Brown et al., 1982; Gepts & Bliss, 1988), usage as green shelled and dry seeds, and more attractive seed colors and shapes. However, the former is less likely because a majority of accessions were dry beans.

Approximately 8 % of the accessions were heterogeneous and exhibited two, three or four phaseolin protein patterns mainly in the most frequent Nueva Granada race. This heterogeneity may be attributed to higher level of cross-pollination among beans (Ibarra-Pérez et al.,1997; Vanderborght, 1982) in the Iberian Peninsula than in other regions or deliberate maintenance of mixture of genotypes within landraces by home gardeners and subsistence farmers.

Among morphological traits, size and shape of the terminal trifoliolate leaflet, flower bracteoles, and dry seed; the presence or absence of stripes at the outer base of the flower standard and pod beak position were the most useful traits to identify the Andean versus Mesoamerican origin and the race affiliations (Table 3). As noted earlier, these characters also indicated that most landraces originated in South America, and conform to races Nueva Granada and Peru (Table 3). A noteworthy finding of this study was the identification of Mesoamerican (e.g., PHA-0399, 66 g 100-seed weight^{-1}) and Andean (e.g., PHA-0917, 119 g 100-seed weight^{-1}) accessions with exceptionally large seeds not found among the Latin

American collections. Moreover, there were accessions that did not have characteristics typical of either Andean or Mesoamerican gene pools. These forms had morphological traits and phaseolin and isoenzymes profiles (Santalla et al., 2002) that did not correspond with the characterization of the Andean and Mesoamerican gene pools as described by Singh et al. (1991a). Instead, they were intermediate forms or recombinants between the two gene pools (Table 3). These inter-gene pool recombinants may be of interest to breeders and geneticists because they could constitute bridging-germplasm that may aid in the transfer of useful genes between the two gene pools. Thus, these accessions may merit further studies.

The need for preserving important common bean germplasm has led to the creation of several large collections such as those maintained at CIAT, Cali, Colombia (Debouck, 1999; Hidalgo, 1991) and USDA-ARS, Pullman, Washington, USA (Silbernagel & Hannan, 1988). However, in order to effectively manage and utilize such large germplasm collections, a smaller, more manageable subsamples or core collections are being developed. For example, recently Skroch et al. (1998), Tohme et al. (1995) and Zeven et al. (1999) reported formation of common bean core collections. Thus, we also selected 52 (13 %) accessions to form a core collection (Table 4) that represent the phenotypic variation among 388 common bean accessions from the Iberian Peninsula. The range for most traits among 52 accessions of the core collection and among 388 base accessions was similar (Tables 1 & 2). Additionally, all relevant market classes identified in the base collection were represented in the core despite its reduced number of accessions (Table 4). Thus, the core collection is representative of the common bean collection from the Iberian Peninsula. The initial screening of these core accessions for resistance to abiotic and biotic stresses and other agronomic traits could provide a clue as to in which group of landraces and garden forms to explore for additional favourable alleles and quantitative trait loci (Tohme et al., 1995; Zeven, 1999). However, the effectiveness of a core collection as a tool for understanding and utilizing crop germplasm will depend on its extensive characterization and representation of the genetic diversity it contains (Skroch et al., 1998). As an example, Miklas et al. (1999) used a subsample of the USDA common bean core collection to identify new sources of resistance to white mold [caused by *Sclerotinia sclerotiorum* (Lib) de Bary].

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Table 1. Mean, standard deviation and range for 34 quantitative traits in the base and core collection of common bean from the Iberian Peninsula evaluated at Pontevedra, Spain in 1998 and 1999

Character	**Base collection**		**Core collection**	
	Mean - standard deviation	Range	Mean - standard deviation	Range
Days to first flower	48.8 ± 7.4	37.0 - 76.0	48.0 ± 7.5	37.0 - 67.0
Days to 50% flowering	52.2 ± 8.2	39.0 - 78.0	50.2 ± 7.5	39.0 - 70.0
Days to end flowering	77.2 ±13.5	56.0 - 129.0	78.8 ± 15.2	56.0 - 129.0
Duration of flowering (days)	25.0 ± 9.7	3.0 - 63.0	27.8 ±10.6	13.0 - 62.0
Days to pod maturity	67.8 ± 11.7	51.0 - 122.0	67.0 ± 13.2	55.0 - 121.0
Days to first dry pod	90.1 ± 18.0	71.0 - 168.0	90.2 ± 19.5	71.0 - 168.0
Length of leaflet (cm)	9.64 ± 1.19	5.9 - 12.5	9.83 ± 0.97	7.9 - 12.0
Width of leaflet (cm)	7.33 ± 0.99	5.0 - 10.6	7.53 ± 0.76	6.0 - 9.5
Length/width of leaflet	1.32 ± 0.12	1.0 - 1.7	1.31 ± 0.12	1.0 - 1.6
Length of bracteole (mm)	5.08 ± 0.92	3.5 - 9.0	5.00 ± 0.86	3.7 - 7.4
Width of bracteole (mm)	3.11 ± 0.69	1.7 - 5.8	3.06 ± 0.67	2.0 - 5.2
Length/width of bracteole	1.66 ± 0.23	1.1 - 2,5	1.66 ± 0.22	1.2 - 2.0
Pod length (mm)	118.7 ± 29.4	51.8 - 202.6	119.1 ± 27.1	75.2 - 202.6
Pod width (mm)	12.0 ±1.6	8.4 - 17.4	12.3 ± 1.7	9.1 - 15.7

Character	**Base collection**		**Core collection**	
	Mean - standard deviation	Range	Mean - standard deviation	Range
Pod thickness (mm)	5.86 ± 80	3.9 - 9.0	5.84 ± 0.75	4.3 - 7.2
Pod curvature	1.07 ± 0.10	0.7 - 1.9	1.06 ± 0.09	1.0 - 1.5
Length /width of pod	10.0 ± 2.6	4.9 - 17.5	9.60 ± 2.15	5.7 - 13.7
Width/thickness of pod	2.08 ± 0.33	0.9 - 3.0	2.13 ± 0.33	1.5 - 2.9
Weight of five pods (g)	26.4 ± 11.8	2.1 - 66.6	26.0 ± 11.2	7.8 - 65.3
Number of seeds per pod	4.4 2 ± 1.26	1.0 - 8.5	4.45 ± 1.33	1.3 - 7.0
Number of pods per plant	11.4 ± 7.2	1.0 - 40.5	13.7 ± 9.6	1.5 - 41.4
Pod yield (g/plant)	60.6 ± 40.8	3.3 - 196.8	56.6 ± 37.2	6.7 - 147.2
Seed length (mm)	13.0 ± 3.0	7.9 - 29.0	12.9 ± 2.9	7.9 - 22.0
Seed width (mm)	8.04 ± 1.03	5.8 - 11.9	7.97 ± 1.13	5.8 - 10.8
Seed thickness (mm)	5.83 ± 0.86	3.9 - 8.1	5.93 ± 0.91	4.2 - 8.1
Length/width of seed	1.62 ± 0.26	1.2 - 2.9	1.58 ± 0.25	1.2 - 2.1
Width/thickness of seed	1.39 ± 0.17	1.1 - 1.9	1.37 ± 0.17	1.2 - 1.8
Weight of 100 seeds (g)	40.9 ± 14.4	11.2 - 119.0	42.2 ± 16.8	15.7 - 119.0
Seed yield (g/plant)	11.8 ± 8.4	0.6 - 53.7	12.0 ± 8.6	1.0 - 45.3
Protein content (%)	27.1 ± 1.7	22.1 - 30.7	27.2 ± 1.5	25.0 - 30.1
Fat content (%)	1.69 ± 0.16	1.0 - 2.0	1.61 ± 0.23	1.0 - 1.9

Character	**Base collection**		**Core collection**	
	Mean - standard deviation	Range	Mean - standard deviation	Range
Starch content (%)	44.6 ± 1.5	40.1 - 49.5	44.7 ± 1.7	41.3 - 48.9
Sugar content (%)	4.90 ± 0.47	3.8 - 6.5	4.88 ± 0.59	4.0 - 6.1
Moisture content (%)	12.2 ± 0.5	10.0 - 13.6	12.2 ± 0.5	11.0 - 13.3

Table 2. Frequency (%) of genotypes for 13 morphological characters in the base and core (in parenthesis) collection of common bean from the Iberian Peninsula evaluated at Pontevedra, Spain in 1998 and 1999

Growth habit	**Type I**	**Type II**	**Type III**	**Type IV**
	23.1 (26.9)	17.3 (17.3)	1.4 (7.7)	58.2 (48.1)
Leaflet shape	**Cordate**	**Lanceolate**	**Ovate**	
	14.6 (21.3)	16.8 (12.5)	68.6 (66.2)	
Bracteole shape	**Cordate**	**Lanceolate**	**Ovate**	
	29.5 (27.5)	53.4 (57.5)	17.1 (15.0)	
Flower wing colour	**White**	**Pink**	**Purple**	
	56.8 (51.3)	37.5 (43.9)	5.7 (4.8)	
Flower standard colour	**White**	**Pink**	**Purple**	
	55.9 (51.3)	27.4 (26.8)	16.7 (21.9)	
Stripes on flower standard	**Present**	**Absent**		
	10.9 (17.1)	89.1 (82.9)		
Leaf hairiness	**Sparse**	**Dense**		
	61.6 (65.9)	38.4 (34.1)		

Table 2. Continued.

Pod fibre [1]	**1**	**2**	**3**	**4**	**5**
	25.8 (29.3)	30.9 (19.5)	25.4 (29.3)	15.5 (21.9)	2.40 (0.0)
Pod colour	**Green**	**Yellow**	**Green/purple**	**Yellow/green**	
	87.0 (85.3)	6.5 (2.5)	5.8 (9.8)	0.7 (2.4)	
Pod beak position	**Placental**	**Central**			
	86.9 (90.2)	13.1 (9.8)			
Pod beak curvature	**Curved**	**Straight**			
	73.5 (78.1)	26.5 (21.9)			
Pod shape	**Flat**	**Round**			
	96.6 (100.0)	3.4 (0.0)			

Table 2. Continued

Primary seed colour	**White**	**Cream**	**Yellow**	**Pink**	**Red**	**Brown**	**Purple**	**Black**	**Bicolour**
	42.6 (44.1)	25.0 (21.2)	5.0 (0.0)	2.5 (0.0)	9.8 (5.8)	5.8 (17.3)	0.7 (0.0)	6.1 (5.8)	2.5 (5.8)
Seed shape	**Kidney**	**Round**	**Oval**	**Rhombohedric**					
	40.1 (38.5)	21.6 (28.8)	30.9 (25.0)	7.4 (7.7)					
Seed size	**Large**	**Medium**	**Small**						
	47.9 (51.9)	41.2 (34.6)	10.9 (13.5)						

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[1] Pod fibre scored on a 1 to 5 scale, where 1 = absence of fibre and 5 = highly fibrous.

Table 3. Number of accessions of each common bean race and market classes in the base collection (the number of landraces that could be intermediate forms or recombinants between the Andean and Mesoamerican gene pools is given in italics)

Origin	Race	Market class
Mesoamerican	**Mesoamerica**	Small white (29), navy (3), mulatinho (5), carioca (1), negro brillante (2), chumbinho (1), black turtle (3), small red (1), small yellow (1) *1 small white, 1 small yellow*
	Durango	Large great northern (10), great northern (26), pinto (6) *6 large great northern, 1 great northern*
	Jalisco	Small white kidney (4), rosada (1), brown mottled (1), marrow (2)
Andean	**Nueva Granada**	Azufrado (12), rosada (9), bayo gordo (4), viscado (4), mottled canellini (7), black canellini (3), black mottled (2), brown garbanzo (2), brown mottled (6), canela (22), canellini (42), dark red kidney (13), cranberry (2), dark garbanzo (5), favada (15), favada pinto (1), small red pinto (14), large cranberry (18), large red mottled (5), light red kidney (1), manteca (6), sargaço (5), white kidney (29), red pinto (3) *5 canellini, 5 favada, 7 small red pinto, 2 white kidney*
	Peru	Ojo de cabra (8), bayo gordo (8), brown garbanzo (2), canario bola (5), cranberry (13), hen eye (1), marrow (29), morado (1), purple caparron (1), red caparron (6), rounded caparron (2) *1 bayo gordo, 6 marrow*
	Chile	Bayo gordo (2), cranberry (3), garbancillo (4), brown garbanzo (1), morado (1), negro brillante (16)

Table 4. Race, market class and key characters of the 52 landraces that form the Iberian Peninsula common bean core collection.

Identification	**Collection region / local name**	**Growth habit**	**50 % flowering (days)**	**Leaflet shape [1]**	**Bracteole shape [1]**	**100-seed weight**	**Seed color / shape**	**Phaseolin**	**Market class**
Gene pool: Mesoamerican									
Race: Mesoamerica									
PHA-0107	Macedo de Cavaleiros, Bragança, Portugal	IV	49	C	C	28	white / oval	B	Small white
PHA-0188	Vimianzo, A Coruña, Spain	IV	61	O	C	28	white / oval	B	Small white
PHA-0523	El Barco de Ávila, Ávila, Spain / Arrocina	II	48	O	L / O	16	white / round	B	Small white
PHA-0471	Pravia, Asturias, Spain / Chichos blancos	I	54	L / O	L / O	17	white / oval	S	Navy
PHA-0663	Vilapouca de Aguiar, Vila Real, Portugal / Feijao roxo	III	49	C / O	C	25	brown / kidney	B	Mulatinho
PHA-0632	Ricla, Zaragoza, Spain	IV	55	O	C / L	29	brown/ oval	S	Chumbinho
PHA-0414	Pravia, Asturias, Spain / Chichos amarillos	I	44	C	L	28	cream / round	S	Small yellow
PHA-0678	Lindoso, Vila Real, Portugal / Moleirinho	II	52	L / C	O	19	red / kidney	B	Small red

Identification	Collection region / local name	Growth habit	50 % flowering (days)	Leaflet shape [1]	Bracteole shape [1]	100-seed weight	Seed color / shape	Phaseolin	Market class
PHA-0247	Asturias, Spain	IV	59	C	L	19	black / oval	B	Black turtle
Race: Durango									
PHA-0399	Pravia, Asturias, Spain / Faba pancha	IV	55	O	C	66	white / rhombohedric	S	Large great northern
PHA-0037	Macedo de Cavaleiros, Bragança, Portugal	I	51	L	O	52	white / rhombohedric	S	Great northern
PHA-0273	Melón, Ourense, Spain	IV	52	C	C	36	white / rhombohedric	S	Great northern
PHA-0587	Fuentesaúco, Zamora, Spain	IV	42	O	C / O	33	white / rhombohedric	S	Great northern
PHA-0573	Valdelacasa, Salamanca, Spain / Pinta	IV	40	C	L	28	cream / oval	S	Pinto
Race: Jalisco									
PHA-0065	Mirandela, Bragança, Portugal	II	47	C	O	41	white / round	S	Samll white

Identification	**Collection region / local name**	**Growth habit**	**50 % flowering (days)**	**Leaflet shape [1]**	**Bracteole shape [1]**	**100-seed weight**	**Seed color / shape**	**Phaseolin**	**Market class**
Gene pool: Andean									
Race: Nueva Granada									
PHA-0582	Guernica, Vizcaya, Spain	IV	59	O	C / L	52	brown / kidney	H	Brown mottled
PHA-0390	A Cañiza, Pontevedra, Spain	IV	51	O	L	49	brown / kidney	H	Brown mottled
PHA-0105	Mirandela, Bragança, Portugal	II	46	L	L	72	cream / kidney	T	Canela
PHA-0345	A Golada, Pontevedra, Spain	I	44	O	C / L	47	cream / kidney	C	Canela
PHA-0086	Bragança, Portugal	I	43	L	L	50	white / oval	C	Canellini
PHA-0252	Vila de Cruces, Pontevedra, Spain	IV	53	L	L	37	white / kidney	H	Canellini
PHA-0441	Fustiñana, Navarra, Spain	I	41	O	L	35	white / oval	H	Canellini
PHA-0563	La Bañeza, León, Spain	I	50	C	L	43	white / kidney	H	Canellini

Identification	**Collection region / local name**	**Growth habit**	**50 % flowering (days)**	**Leaflet shape** [1]	**Bracteole shape** [1]	**100-seed weight**	**Seed color / shape**	**Phaseolin**	**Market class**
PHA-0521	Horcajo de la Ribera, Ávila, Spain / Alubia morada	I	43	O	L / O	44	red/ kidney	T	Dark red kidney
PHA-0470	Pravia, Asturias, Spain	I	41	O	L	22	brown / kidney	T	Dark garbanzo
PHA-0706	Villaviciosa, Asturias, Spain / Faba	IV	67	O	C	76	white / kidney	T	Favada
PHA-0917	Lourenzá, Lugo, Spain / Faba	IV	70	O	L	119	white / kidney	T	Favada
PHA-0654	Moimenta da Veira, Viseu, Portugal / Tourinho	I	54	L / C	O	65	white, red/ kidney	T	Favada pinto
PHA-0486	Obécuri, Álava, Spain / Guernikesa	III	48	C	C / L	24	red, cream / round	T	Small red pinto
PHA-0303	Sober, Lugo, Spain	IV	50	O	L	45	cream, red / oval	C	Large cranberry
PHA-0552	La Robla, León, Spain	II	50	O	L	44	cream, red / kidney	T	Large cranberry
PHA-0655	Moimenta da Veira, Viseu, Portugal	I	47	O / C	L	40	cream / kidney	C	Sargaço

Identification	Collection region / local name	Growth habit	50 % flowering (days)	Leaflet shape [1]	Bracteole shape [1]	100-seed weight	Seed color / shape	Phaseolin	Market class
PHA-0062	Mirandela, Bragança, Portugal	III	42	L	C	50	white / kidney	T	White kidney
PHA-0178	Mañón, A Coruña, Spain / Riñón	IV	58	O	L	44	white / kidney	T	White kidney
PHA-0225	Vilaboa, Pontevedra, Spain	IV	48	C	L	58	white / round	T	Marrow
PHA-0590	Santa Croya de Tera, Zamora, Spain / Pinta	II	41	O	C / O	37	red, cream / kidney	T / H	Red pinto
Race: Peru									
PHA-0448	Peralta, Navarra, Spain	IV	50	C /O	L	37	black / oval	H	Negro brillante
PHA-0215	Carballeda de Avia, Ourense, Spain	IV	54	O	L	43	brown / kidney	H	Bayo gordo
PHA-0279	Vilar de Barrio, Ourense, Spain	IV	48	O	C	50	cream, red / oval	H	Cranberry
PHA-0577	Requena, Valencia, Spain	I	48	O	C / L	34	cream, red / kidney	T / H	Cranberry
PHA-0476	Pola de Siero, Asturias, Spain / Ollo de pita	IV	69	L / O	L	37	white / rounded	C	Hen eye

Identification	**Collection region / local name**	**Growth habit**	**50 % flowering (days)**	**Leaflet shape** [1]	**Bracteole shape** [1]	**100-seed weight**	**Seed color / shape**	**Phaseolin**	**Market class**
PHA-0036	Freixo Espada, A Cinta, Bragança, Portugal	II	50	C / L	C	36	white / round	T	Marrow
PHA-0210	Sarria, Lugo, Spain	II	48	L	O	42	white / round	H	Marrow
PHA-0589	Muelas de los Caballeros, Zamora, Spain	I	39	O	C / L	43	white / rounded	H	Marrow
PHA-0309	Sober, Lugo, Spain	II	48	L	L	48	white, purple / round	T	Purple caparron
PHA-0565	Santo Domingo de la Calzada, La Rioja, Spain	IV	48	O	L	36	white, red / round	H	Red caparron
PHA-0433	Peralta, Navarra, Spain	IV	69	L	O	41	brown, white / round	C	Rounded caparron
PHA-0407	Pravia, Asturias, Spain / Faba de vino tinto	IV	57	O	O	39	red / round	H	Sangretoro
PHA-0274	Melón, Ourense, Spain	IV	50	O	C	36	brown / round	C	Dark garbanzo
Race: Chile									
PHA-0081	Bragança, Portugal	III	41	L	L	47	cream, red/ oval	H	Cranberry

Identification	Collection region / local name	Growth habit	50 % flowering (days)	Leaflet shape [1]	Bracteole shape [1]	100-seed weight	Seed color / shape	Phaseolin	Market class
PHA-0572	Valverde de la Casa, Salamanca, Spain / Chícharo	I	39	C	C	38	cream / round	C	Garbancillo
PHA-0501	Aia, Guipúzcoa, Spain / Tolosana	IV	48	O	L / O	49	black / oval	H	Negro brillante

(1) O: ovate, L: lanceolate, C: chordate.