Morphological characterization of a small common bean (*Phaseolus vulgaris* L.) collection under different environments

Морфологична характеристика на малка колекция обикновен фасул (*Phaseolus vulgaris* L.) при различни условия на отглеждане

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Abstract

There is a long tradition in the cultivation of pulses in the Balkans and the Iberic Peninsula, mainly used for human consumption. Among the major food legumes common bean is the most important. A large range of landraces are still grown that have adaptation to local climatic conditions and resistance or tolerance to diseases and pests allow high yield stability under a low input farming. The main purpose of this work was to analyze the morphological variability of 15 Portuguese and 15 Bulgarian landraces in different environmental conditions (in Bulgaria and Portugal) in order to generate information that can help identifying the most suitable resources with good adaptability to different environments. The landraces were evaluated for 16 morphological characters. A considerable morphological variation was found among genotypes. The majority of landraces had white seeds colour but some had also cream, purple and white with red colours around the hillum. The predominant seed shape was long but three accessions have round shape. The geographical site of the trials (Elvas, Portugal or Sadovo, Bulgaria) determined the cluster pattern of the majority of accessions. In Portugal, the plants required more days to reach the flowering and maturity phases and had higher biological yield. In both environments, the components that mainly determined yield were the number of pods and the number of seeds per plant. The highest value for these traits were found in one Portuguese accession (№ PH2) and one Bulgarian accession (№ 99E0128), in both experimental conditions.

Keywords: common bean, landraces, morphological characterization

Резюме

Традиционни за Балканския полуостроов са бобовите храни, като фасулът заема достойно място между тях. На много места в България все още се поддържат местните форми фасул, които са добре адаптирани към

микроклимата на района, някои от тях са толерантни към важните за тях заболявания и се отглеждат при минимални вложения. Целта на настоящата работа бе да се анализират морфологичните качества на 15 образци полски фасул с португалски произход и 15 с български произход при различни условия на отглеждане, в България и Португалия. Генотиповете бяха оценени по 16 морфологични характеристики, като бе установено значително морфологично вариране. Компонентите, които определят добива и на двете места бяха брой на бобовете и семената на едно растение. Най-високи стойности за тези показатели бяха отчетени при един португалски (PH2) и един български (99E0128) образци.

Ключови думи: обикновен фасул, местни форми, морфологична характеристика

Introduction

The conservation, study and use of local plant resources is a basic problem for breeding in many countries. This is particularly crucial today, due to the increasing influence of different anthropogenic factors that can affect the genetic diversity of various valuable species (Krasteva et al., 2002). Landraces (LRs) harbor a diversity that is of interest for future breeding work, as well as for developing new products and consequently need to be preserved for future generations (Negri and Tosti, 2002; Stoilova et al., 2004; Stoilova et al., 2005). Thousands of legume species exist, but common beans (*Phaseolus vulgaris* L.) are from far the most consumed. In some countries beans are the primary source of protein in human diet.

Common bean is a traditional crop in Portugal and in Bulgaria, where farmers are still grow old varieties and landraces.

Characterization of germplasm collections is traditionally based on morphological and agronomic traits that are of high interest for breeding work. In some cases, other traits important for producing typical and high quality products are also taken in consideration (Pereira et al., 2005; Stoilova, 2007).

The objectives of the present study were to morphologically characterize accessions belonging to the Portuguese and Bulgarian collections of common beans under different environments, in order to identify accessions with particular interest for plant breeders, researchers and farmers in both countries. The characterization focused on the relationship between morphological variation and geographic distribution and the comparison between Bulgarian and Portuguese populations.

Materials and Methods

Thirty landraces were evaluated in the present study, originated from Portugal and Bulgaria (Table 1).

Table 1. Accessions of beans studied and their origin

№	Accession number	Country origin	№	Accession number	Country origin
1.	PH1	Portugal	16.	A3E001	Bulgaria
2.	PH2	Portugal	17.	AOE0005	Bulgaria
3.	PH5	Portugal	18.	AOE0007	Bulgaria
4.	PH7	Portugal	19.	91E0300	Bulgaria
5.	PH8	Portugal	20.	91E0293	Bulgaria
6.	PH10	Portugal	21.	92E0056	Bulgaria
7.	PH11	Portugal	22.	91E0287	Bulgaria
8.	PH12	Portugal	23.	97E0003	Bulgaria
9.	PH23	Portugal	24.	97E0005	Bulgaria
10.	PH37	Portugal	25.	97E0006	Bulgaria
11.	PH43	Portugal	26.	97E0012	Bulgaria
12.	PH50	Portugal	27.	97E0011	Bulgaria
13.	PH51	Portugal	28.	99E0059	Bulgaria
14.	PH71	Portugal	29.	99E0123	Bulgaria
15.	PH75	Portugal	30.	99E0128	Bulgaria

The bean accessions were grown in the Institute of Plant Genetic Resources (IPGR) at Sadovo, Bulgaria and in the experimental station at Elvas, Portugal. The field trials were in a randomized complete block design with three replications. Each accession was grown in two row plots. In each plot, 10 plants per replication were randomly chosen for biometric measurements. Observations were made for 16 morphological characters: (1) days from sowing to flowering, (2) flowering duration, (3) days from sowing to maturity, (4) flower colour, (5) plant height, (6) number of brunches, (7) height of ^{the} first pod, (8) biological yield, (9) number of pods per plant, (10) weight of pods per plant, (11) pod length, (12) pod width, (13) number of seeds per plant, (14) weight of seeds per plant, (15) colour, and (16) shape of seeds. The morphological characterization was done according to IBPGR descriptors for *Phaseolus* (IBPGR, 1983)

Data were analysed by numerical taxonomy techniques, using NTSYS-pc package, version 2.01 (Rohlf, 1997). An unweighted pair-group method of the arithmetic average clustering procedure (UPGMA) was employed to construct dendrograms. Principal components analysis was applied using the standardized quantitative characters.

Results

The majority of Bulgarian landraces have white flowers and seeds, while only two Portuguese accessions have white colour, the others having lilac flowers and brown seeds (Table 2). In this collection 17 accessions have kidney shaped seeds, 10 have cuboid seeds and one accession has oval shaped seeds. Two accessions PH1 and PH37 did not reach maturity and did not give seeds.

Table 2. Qualitative traits observed on 30 landraces of beans tested in Portugal and in Bulgaria

Accession	Flower	Seed	Seed	Accession	Flower	Seed	Seed

number	colours	colours	shape	number	colours	colours	shape
PH1	white	-	-	A3E001	white	white	kidney
PH2	lilac	red	kidney	AOE005	white	bicolour	kidney
PH5	white	white	kidney	AOE007	white	white	kidney
PH7	lilac	brown	kidney	91E300	white	white	kidney
PH8	lilac	red	kidney	91E287	white	white	cuboid
PH10	lilac	red	kidney	91E293	lilac	brownish	kidney
PH11	lilac	brownish	cuboid	92E056	white	white	cuboid
PH12	lilac	brownish	cuboid	97E003	white	white	cuboid
PH23	white	white	oval	97E005	white	white	cuboid
PH37	white	-	-	97E006	white	white	cuboid
PH43	white	bicolour	kidney	97E012	white	white	kidney
PH50	lilac	brown	kidney	97E0011	white	white	kidney
PH51	lilac	brownish	kidney	99E0059	white	white	cuboid
PH71	white	white	kidney	99E0123	white	white	cuboid
PH75	white	white	kidney	99E0128	white	white	cuboid

Minimum and maximum values and coefficient of variation for quantitative characters are presented in Table 3. The most variable characters were the number of pods per plant, weight and number of seeds per plant, weight of plant, and weight of pods per plant. The biggest value for weight and number of seeds per plant were observed for the Portuguese accessions PH2, PH7, PH75 and the Bulgarian accessions 99E0128, 99E123 and 99E059. Duration of the different phenological phases showed less variation. Bulgarian landraces were characterized by an earlier maturity than Portuguese accessions. Two Portuguese accessions PH2 and PH11 had a growth cycle of about 74 days.

Table 3. Minimum, maximum and coefficient of variation (CV%) for the morphological characters

Characters	Minimum		Maximum		CV (%)	
	Elvas	Sadovo	Elvas	Sadovo	Elvas	Sadovo
Biological yield (g)	28.6	21.0	122.6	123.4	38.0	48.4
Plant height (cm)	35.8	19.5	92.5	101.2	28.1	43.3
Height of 1st pod (cm)	8.1	10.2	41.9	28.0	43.6	27.5
Number of pods*plant^{-1}	1.0	6.4	42.7	20.6	65.4	24.5
Weight of pods*plant^{-1} (g)	1.0	8.7	44.3	29.3	63.3	25.1
Pod length (cm)	6.8	8.9	11.0	12.9	11.4	8.0
Pod width (cm)	0.9	0.9	1.3	1.3	9.4	9.0
Number of seeds* plant^{-1}	2.0	19.9	64.0	53.9	67.0	25.2
Weight of seeds*plant^{-1} (g)	0.5	7.2	27.0	19.9	67.3	23.3
100 seeds weight (g)	20.0	25.3	67.5	55.7	28.1	16.7
Days to flowering	44.0	30.3	76.0	50.3	13.5	14.0
Flowering duration (days)	22.0	12.0	32.0	16.7	9.5	8.7
Days to maturity	107.0	71.7	150.0	86.3	10.5	4.7

To understand better the overall diversity of common bean landraces, the data collected were analyzed by Principal Component analysis and Cluster analysis

(Figure 1A, 1B; Figure 2A, 2B and Figure3). The first componente explained 34,5% of the total variation, in Elvas and 33,5% in Sadovo"(Table 4).

Table 4. Total variance explained by each component in Elvas-Portugal and Sadovo-Bulgaria

i	Elvas –Portugal			Sadovo-Bulgaria		
	Eigenvalue	Percent	Cumulative	Eigenvalue	Percent	Cumulative
1	4.14	34.48	34.48	4.02	33.47	33.47
2	3.16	26.37	60.85	2.98	24.82	58.29
3	1.49	12.42	73.27	1.70	14.16	72.45
4	1.12	9.34	82.61	0.93	7.73	80.18
5	0.58	4.85	87.46	0.72	5.98	86.16
6	0.51	4.22	91.69	0.56	4.69	90.85
7	0.33	2.78	94.46	0.37	3.10	93.95
8	0.23	1.94	96.40	0.30	2.51	96.46
9	0.20	1.65	98.05	0.26	2.18	98.64
10	0.15	1.27	99.32	0.08	0.63	99.27
11	0.05	0.39	99.71	0.06	0.48	99.75
12	0.03	0.29	100.00	0.03	0.25	100.00

Both in Portugal (Elvas) and Bulgaria (Sadovo) the characteristics responsible for separation along the first principal component were the number of pods and seeds per plant and the weight of pods and seeds per plant (Table 5).

Table 5. Correlation of principal components with original quantitative characters

Caracter	Elvas –Portugal			Sadovo-Bulgaria		
	1	2	3	1	2	3
Wplant	0.577	0.680	0.037	0.078	0.739	0.347
Height	-0.032	0.889	-0.203	-0.120	0.765	0.078
H1stpod	-0.298	0.738	-0.363	0.229	0.684	0.527
Npod*pl^{-1}	0.955	0.017	-0.136	-0.920	0.094	-0.006
Wpods*pl^{-1}	0.968	-0.036	-0.140	-0.961	0.054	0.128
Lpod	-0.114	-0.299	-0.337	0.347	-0.390	0.323
Wpod	-0.082	0.284	0.762	0.414	0.361	0.400
Nºseeds*pl^{-1}	0.911	-0.056	-0.262	-0.928	0.174	0.137
Wseed*pl^{-1}	0.864	-0.024	0.035	-0.929	0.171	0.106
DFLO	-0.172	0.810	-0.087	0.372	0.754	-0.213
PFLO	0.432	-0.206	0.588	-0.088	0.321	-0.799
DMAT	0.234	0.703	0.400	0.117	0.595	-0.549

The most productive accessions were PH23, PH2 (PT) and 99E059 and 99E0123 (BG) (Figure 1A and 2A) in both Bulgaria and Portugal. The accessions PH51, PH12, PH10 and PH50 situated on the opposite side were characterized by low yield values.

The combination of number of pods and seeds per plant with early maturity is the main purpose for breeders. In Figure1A, B and Figure2A, B, the accessions with longer vegetation period were PH7, PH8, PH1 and PH37, all from Portuguese origin. Landraces with Bulgarian origin had comparatively shorter growth cycle between 74 and 78 days. The dendrogram (Figure 3) based on morphological data obtained in both countries shows that the geographical site of the trials (Elvas, Portugal and Sadovo, Bulgaria) determines the cluster pattern of the majority of accessions. These results confirm a big diversity among all bean accessions which were studied.

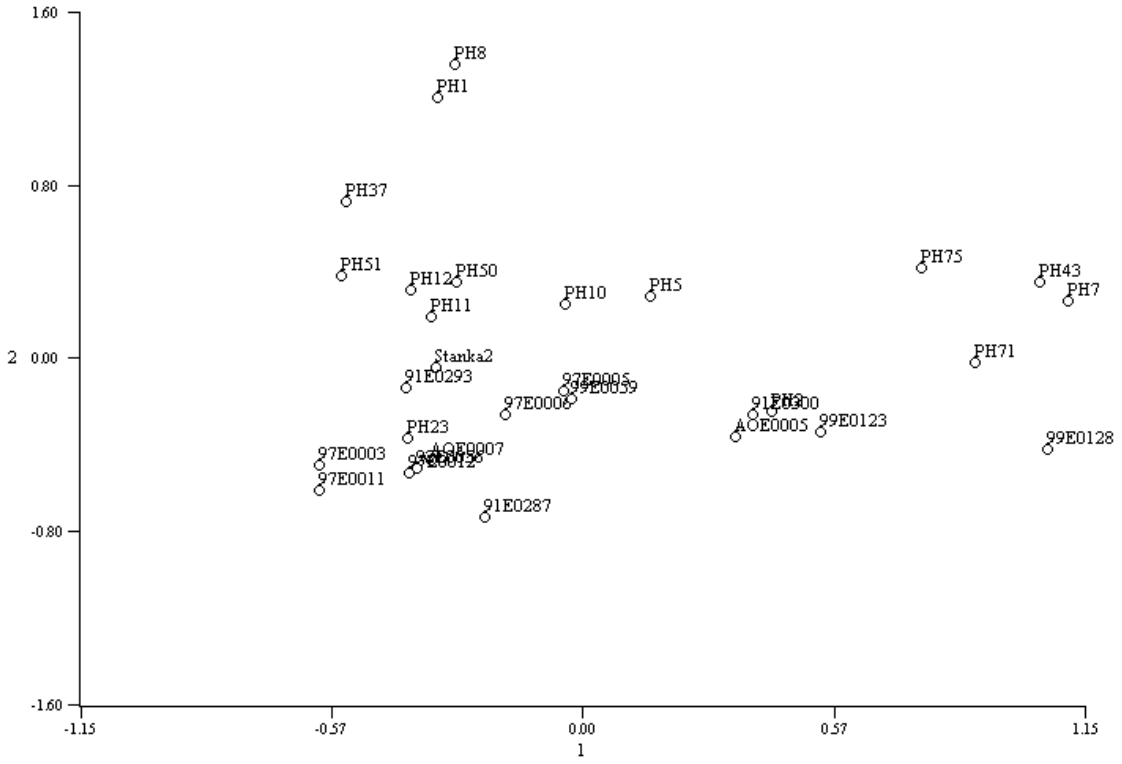

Figure 1A. Principal component analysis of the 30 accessions study in Portugal in axe 1 and 2.

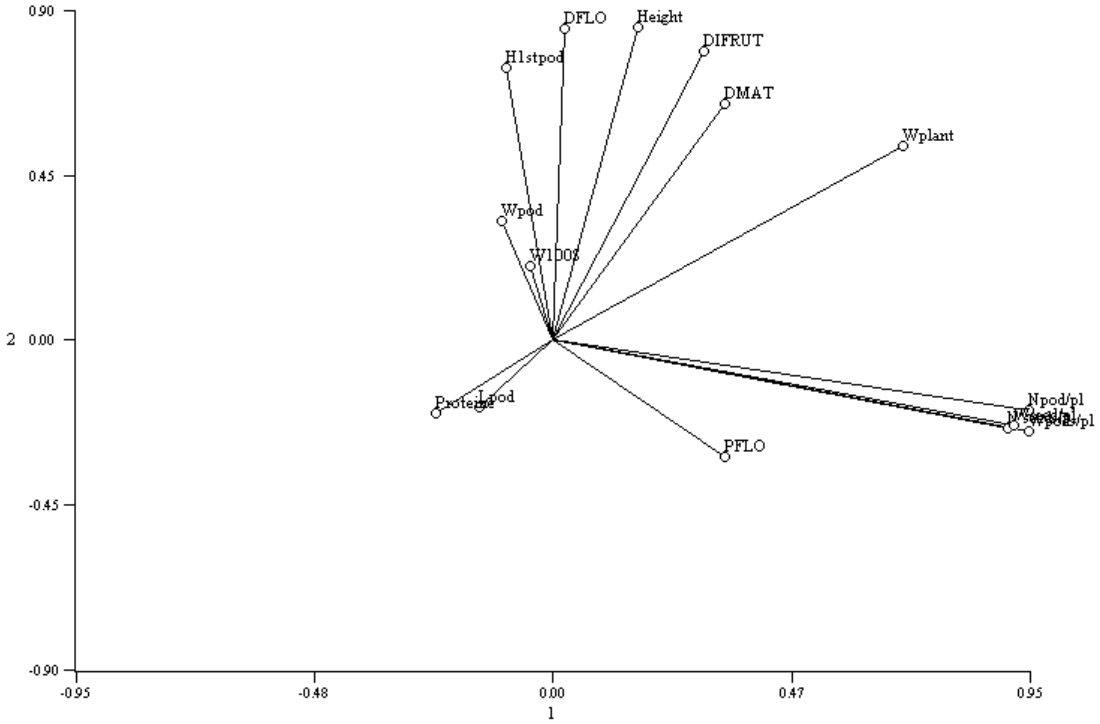

Figure 1 B. Projection of the morphological characters in axe 1 and 2.

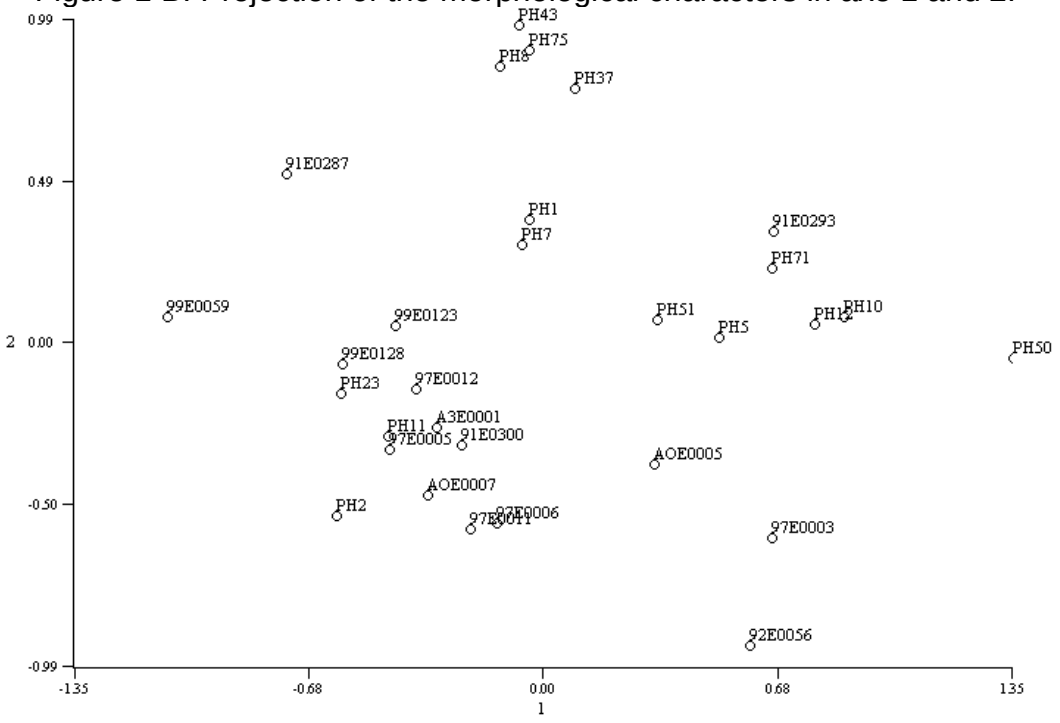

Figure 2 A. Principal component analysis of the 30 accessions study in Bulgaria in axe 1 and 2.

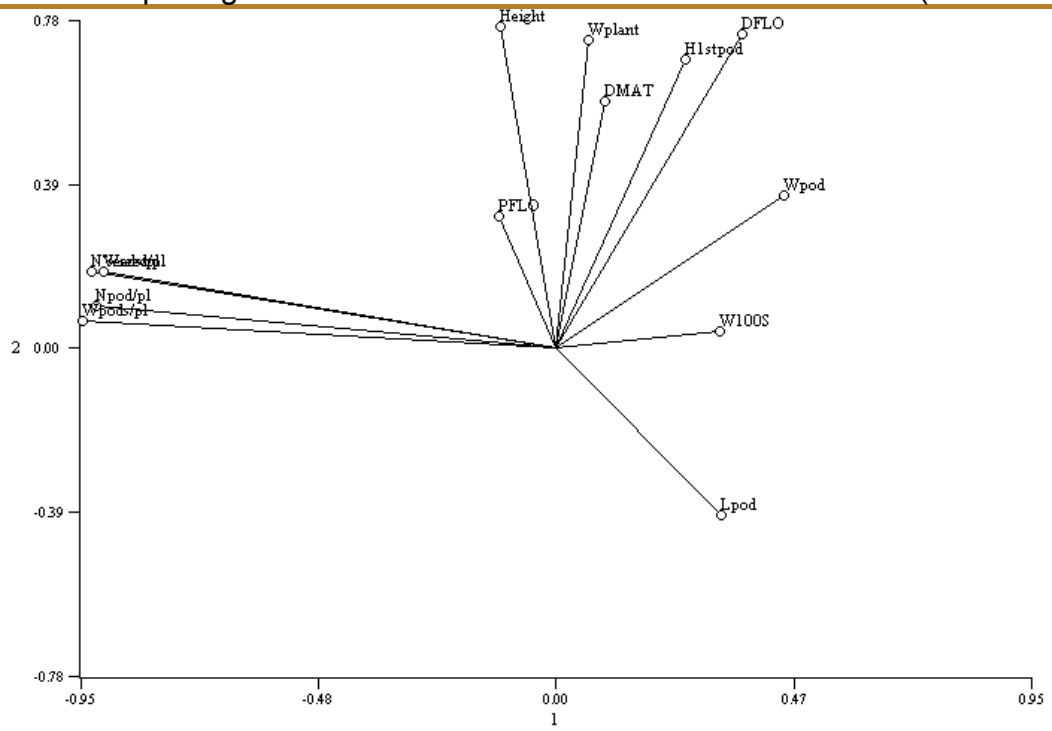

Figure 2 B. Projection of the morphological characters in axe 1 and 2.

Fig.2 A Principal component analysis of the 30 accessions stu
in axe 1 and 2.

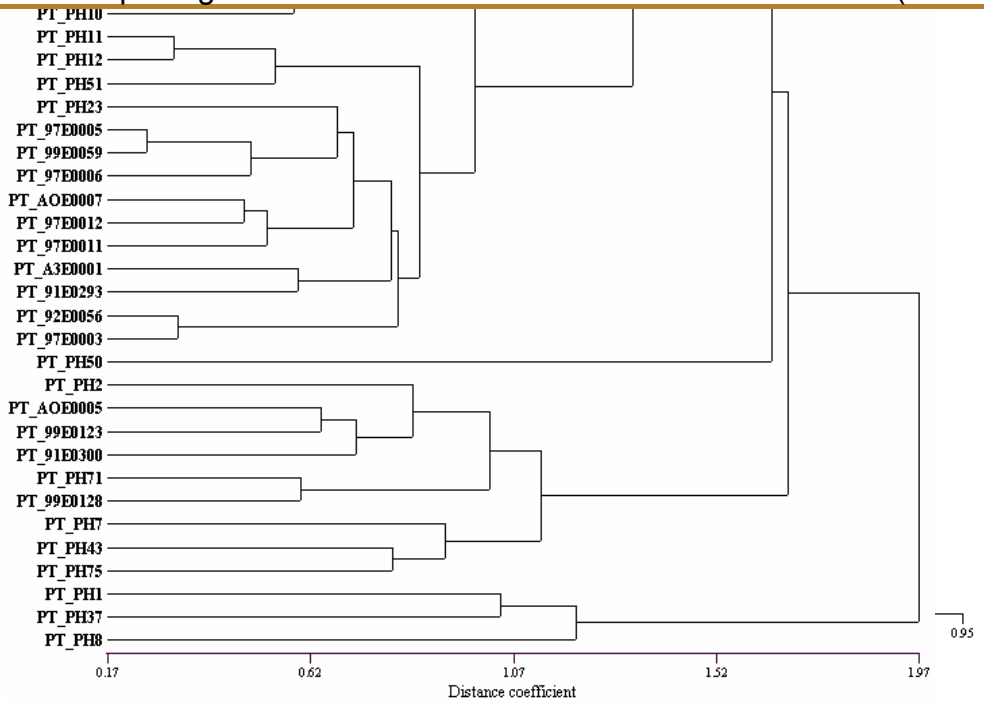

Figure 3. Dendrogram of 30 bean accessions obtained by analysis of morphological data observed in Portugal (PT) and in Bulgaria (BG).

Discussion

Grain legumes have an important role in dry land farming systems. These crops provide high amount of crude protein used for human consumption and animal feeding. The rational use of germplasm collections requires a good knowledge about their characteristics. Well characterized and documented *ex-situ* germplasm collections can consequently provide useful information to plant breeders. Data on the genetic variability among Portuguese populations have been studied by different approaches, but a small number of accessions were characterized morphologically.

The present data indicate a wide variability among both Bulgarian and Portuguese landraces. This result was expected as landraces are the result of several years of natural and artificial selections by farmers for better adaptation to local growing conditions, with different types being preferred by farmers in different regions of (Harlan, 1976). A large variation was observed between studied landraces (Stoilova and Sabeva, 2006). For example, indeterminate type is predominantly grown in the mountainous regions because with high air humidity and low temperatures during the crucial phases. Conversely, determinate type is grown mainly in under dry environments.

One of the most important characters is the duration of the growth cycle and its different phases. During the flowering and pod filling phases temperatures often rise very fast and plants develop under drought stress conditions which limit the productivity of the plants (Berova et al., 2001; Berova et al., 2005). Short duration of those phases can permit the crop to escape drought. These two characters were noted to have a small variation which could however be utilized in breeding programs.

The landraces from both origins possess the highest genetic variation for biological yield and plant height. The comparison of minimum and maximum values for pod length, pod width and 100 seeds weight showed similar variation in both places, suggesting a relative stability of these traits across environments. The most important characters for yield production are pods per plant and seeds per plant (Hegde and Mishra, 2009). The accessions with high number of pods and seeds per plant were the Portuguese landraces PH2, PH7 and PH75 and the Bulgarian landraces 99E0123, 99E0128 and 99E059. The high value of pods and seeds per plant can be utilized for improvement of beans potential productivity.

The color, shape and size of seeds are of special attention for consumers. They preferred different colors of grains. In most regions of Bulgaria, farmers grow landraces with white color of seeds but in the mountainous regions brown, reddish and mottled seeds are often preferred. In both countries consumers prefer seeds with medium or large size.

Conclusions

The evaluation of quantitative and qualitative traits gives the possibility to choose and include the most adapted accessions in future breeding activities or to conserve and use them for typical production with high quality. The most important components of yield are: the highest value for number of pods and seeds per plant. Two components that highly determine grain yield, were found in one Portuguese accession (PH2) and one Bulgarian accession (99E0128). These results provided information about the diversity and breeding value of the Portuguese and Bulgarian germplasm. The scientific information obtained from this study is useful for others gene banks, breeding programs and farmers.

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