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DIVERSITY OF COMMON BEAN LANDRACES (*PHASEOLUS* SPP.) MAINTAINED IN HOME GARDENS IN BULGARIA

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Abstract

Dry bean is considered as one of the major legume crop with big number of landraces grown in Bulgaria. The aim of this study was to characterize landraces of Phaseolus spp. typically grown in home gardens. Studied plant materials were selected according to their importance and distribution, concerning traditions and culture for each region. The most popular local forms were characterized by different approaches. In this paper we will present results from morphological and agro-biological characterization, and phythopathological evaluation. During vegetation cycle of three consequences years 16 qualitative and quantitative traits were assessed on 55 accessions of Phaseolus spp. Phaseolus landraces showed high seed diversity, in terms of seed size, seed shape and seed color. Seed size was analyzed by 100 seed weight. Most of the studied accessions were scored with sensitive reaction to bacterial diseases (Xanthomonas campestris pv. Phaseoli) and only few accessions were identified with middle sensitive reaction.

Key words*: characterization, common bean, diversity, evaluation, local origin.*

INTRODUCTION

Grain legumes provide high quality proteins for many people of the world. Among the pulse crops dry beans (*Phaseolus vulgaris* L.) are the second most important legume crop after soybean. Dry beans are an important staple food in many cultures around the world; it is one of the basic food in Latin America, India and Africa (Seidel, 2022). A big genetic and phenotypic diversity was observed in many countries where it is grown in a wide range of environments to which it is adapted (De Ron et al., 2016). Dry beans are grown in almost all European member countries whereas Spain is one of the main producer and consumer (CBI, 2022). Savic et al. (2019, 2021) studied phenotypic and microsatellite markers diversity of Serbian collection of common beans and proved to be polymorphic, whereas landraces displayed higher variability compared to cultivars included in this study. Pipan & Meglic (2019) conducted a study to define level of diversification of common bean (*Ph. vulgaris* L.) from western to eastern line of Southern European countries, from Portugal to Ukraine. The authors concluded that the collection of 782 accessions represented a valuable source of genetic variability. In Brasil seventeen common bean genotypes were examined on genetic diversity of agronomic traits, the authors selected superior genotypes and defined promising crosses (Ribeiro et al., 2022). In Bulgaria dry beans is considered as one of the major traditional legume crop with big number of landraces grown all over the country by both commercial and small scale farmers (Stoilova, 2013). Landraces are developed by farmers over many generations and are well adapted to specific climatic conditions. They are plants with high ecological plasticity, with good behaviour to abiotic and biotic stress factors. Most farmers prefer old populations and primitive varieties hence the large diversity of these populations and excellent organoleptic taste. Farmers still keep their seeds and grown in home gardens in rural and marginal areas (Savic et al., 2021). They are traditionally grown under low input farming system, adapted to local agro-climatic conditions and display high level of phenotypic diversity (Carovic et al., 2017). Nevertheless, there is a risk of extinctions of many landraces due to aged farmers, new bred cultivars and the socio-cultural context where they are maintained (Mallor et al., 2018) The national bean collection is preserved at the National Genebank which belongs to the Institute of Plant Genetic Resources (IPGR), Sadovo. The collection consists at about 2200 accessions,

with local and foreign origin (Stoilova et al., 2013). The big number of landraces collected during several decades provide opportunity to select the most suitable of them for the respective breeding objectives or to be repatriated to the farmers for direct use, in case of farmer's interest. On recent years, several bean populations and landraces mostly belonging to *Ph. vulgaris* and *Ph. coccineus* were collected, characterized and evaluated (Stoilova, 2011). Characterization of genetic resources remained the first step to investigate the level of variation of morphological, agro-biological and agronomic traits which can be used for crop improvement in terms of high yield potential with better quality of production, very good organoleptic taste, biotic and abiotic stress tolerance. Characterization and evaluation are of main importance for conservation plant genetic material *ex situ* in genebank or *in situ*/on farm in their origin in view of future breeding and research work under global climate change. The aim of our study was to make a complex morphological, agro-biological and agronomic characteristics of the 55 accessions, landraces with local origin in view of their better utilization and conservation.

MATERIALS AND METHODS

The study took place from 2020 to 2022 at the experimental field of IPGR, Sadovo (49◦9′N, 24◦57′S and 158m a.s.). The study was carried out on 55 common bean (*Ph. vulgaris* L.) accessions with local origin from different regions of the country (Figure 1).

Sowing took place in first half of April depending from the meteorological conditions during the certan period. The field trial is sown on cinnamon-forest soil and usually follow the predecessor cereals. All accessions were sown in three replications on an experimental plot of 5.6 m^2. Basic phenological stages, morphological and agronomic traits were recorded during the vegetation period, using Bioversity International Phaseolus descriptor (1982). Ten plants from each accession per replication were taken for biometric measurements. The phenological observations were done on number (nr) of days to reach 50% flowering, duration of flowering, nr of days to maturity (95% matured plants), while the vegetative and reproductive organs were measured during full developed height of plants, leaves, pods and seeds. Observations on resistance to two bacterial diseases, caused by the pathogens, *Xanthomonas axonopodis* pv. *phaseoli* and *Pseudomonas syringae pv. phaseolicola* were made using the score 1-9, based on method of Genchev & Kiryakov (2005) and Bioversity Int. (1982).

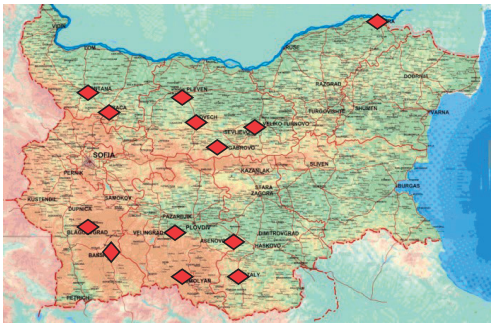

Figure 1. Origin of studied accessions.

Cluster analysis and Principal Component Analysis (PCA) were performed by UPGMA method on 19 quantitative and qualitative traits using SPSS statistical programme.

RESULTS AND DISCUSSIONS

The accessions included in this study needed 59.1 days (mean value) to reach 50% flowering (Figure 2). Four accessions, cat. No 811355, cat. No 741356, cat. No 761376, cat. No 62258 showed the longest period to reach flowering and maturity stages with 69 and 98 days, respectively. Two accessions, cat. No A7E0668 and cat. No B9E0001 started flowering earlier, after 53 days, compared with all other accessions they reach maturity for shorter period of 81 days. Duration of flowering (DurFl) ranged from 30 to 40 days, the shortest flowering period of 30 days was registered in 54.5%, the longest period of 40 days flowering was observed in 31% and rest of accessions 14.5% were with mean number of days - 33-35 (Figure 2).

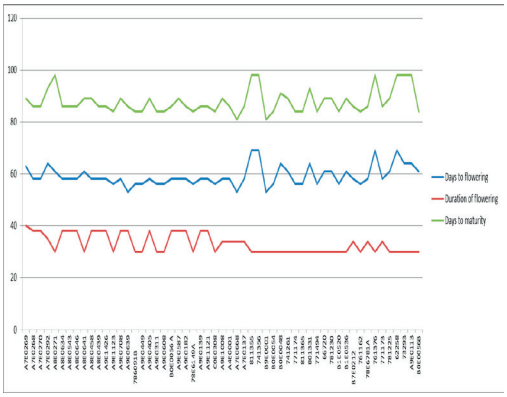

Figure 2. Phenological stages of 55 accessions

Coefficient of variation of the three phenological characters showed low values, as follows: DF-6.6%, DurFl-11.1% and DM - 5.3%, respectively (Table 1). Duration of flowering differs by growth habit of plants, where accessions with indeterminate type flowered and matured for longer cycle compared with accessions possessing determinate growth habit.

Table 1. Descriptive statistics of phenological characters of common beans

Statistical values	Days to 50% flowering (DF)	Duration of flowerring (Dur.Fl.)	Days to 95% maturity (DM)
Minimum	53	30	81
Maximum	69	40	98
Mean	59,1	33,1	87,8
Standard Error	0,5	0,5	0,6
CV (%)	**6,60**	**11,10**	**5,30**

Morphological traits (h of plant, weight of pl., number of branches, weight of pl./without pods, h of 1st pod, number of pods/pl., weight of pods/pl., pod length, pod width and pod thickness. Plant growth habit of studied accessions belonged to determinate /erect type - 61.8% and indeterminate/ climbing type 38.2%. Consequently, morphological traits, as follows: h of plant, weight of plant and weight of plant/without pods were with highest value of coefficient of variation (Table 2). Accessions with cat. No A8E0641, A9E0311, A9E0182, 771174, 801331, B7E0212, 761376, 73293 were with the biggest plant weight (weight of plant without pods-WPWP) > 30 g, at the same time 25 accessions showed less than 10 g WPWP. Twenty two accessions were between 10 and 30 g. It needs to be noticed plant growth habit was not connected with weight of plant and weight of plant without pods. Some of the accessions with indeterminate type didn't reveal their potential growth habit under agro-climatic conditions of Sadovo. High T◦C and low relative humidity (RH%) during flowering and beginning of podding stages which caused heat stress resulted in abortion of flowers and young pods, leaded to low yield production. Similar results were reported by Da Silva et al. (2020) and Vargas et al. (2021). Number of pods and weight of pods per plant showed high value of CV (%) - 44.09 and 44.62%. Different genotypes produced different number of pods, with range from 3.6 to 20 with mean value of 8.2 pods/pl. and CV (%) - 44.1. Accession with cat. No 741261 produced the biggest number of pods (20) and three accessions (A9E0608, B9E0001 and 781230) >15 pods/plant. All mentioned accessions had erect growth habit and were comparatively early maturity (81-84 DM). Pod length ranged between 6.7 to 14.1 with mean value of 9.5 cm and variation among all accession was the lowest with CV-15.8%

Table 2. Morphological traits of 55 accessions of common bean

Cat.№	h of plant (cm)	Weight of plant (g)	Number of branches	Weight of plant/without pods (g)
A7E0269	33,24	18,4	2	8,2
A7E0268	24,8	15,3	2	7,6
A7E0270	29	9,4	3	3,5
A7E0292	34,2	13,0	2	7,0
A8E0271	107,2	17,0	3,2	11
A8E0634	113	38,5	3,6	29,1
A8E0543	106,8	8,9	3	4,9
A8E0646	31,8	33,5	3,8	17,9
A8E0641	100,2	51,1	3	34,1
A8E0458	39	21,4	3	15,2
A8E0439	78,6	22,2	3,1	14,0
A9E1426	34,8	9,3	2,6	3,9
A9E1123	80	22,4	3	15,5
A9E0708	107,6	12,1	3	9,5
A9E0639	30,8	7,1	2	3,6
786091B	39	15,3	2	5,2

Cat.№	h of plant (cm)	Weight of plant (g)	Number of branches	Weight of plant/without pods (g)
A9E0449	78,4	21,3	3	9,1
A9E0405	65,4	13,5	2,2	6,4
A9E0311	96,3	53,2	2,3	44,6
A9E0608	32,2	41,8	2,2	18,1
B0E0056 A	39,6	22,5	2,2	8,9
A9E0587	100,6	24,5	3	9,8
A9E0182	67,8	64,1	3	40,0
78E6149A	34,8	13,6	2	6,0
A9E0139	37,2	20,8	2,2	12,7
A9E1121	36,4	28,9	2	12,6
C0E0308	111,2	18,8	3	12
A9E1008	33,2	19,9	2,2	11,4
A4E0001	33,2	14,3	2,2	5,8
A7E0668	37,6	14,9	2	4,9
A7E0137	41	9,7	3	5,0
811355	54,2	15,6	2,4	9,3
741356	105	30,8	3	16,9
B9E0001	37,4	34,5	3	19,4
B0E0054	39	15,8	2,4	4,1
B0E0048	41,6	32,3	2,2	22,3
741261	40,8	33,5	2,8	15,5
771174	38,8	37,1	2,8	31,9
811365	35	15,5	2	9,5
801331	41	44,8	3	30,4
771494	40,8	31,6	2,2	10,0
66720	33,4	22,4	2	5,2
781230	38,4	33,7	2,8	18,2
B1E0520	38,2	24,6	2,6	13,2
B1E0536	27	18,4	2,4	10,3
B7E0212	125,2	46,2	4	31,8
761162	29,8	12,2	2	3,8
78E6781A	33,6	29,8	2,2	11,8
761376	106	49,5	3	39,0
771173	109,6	22,3	3,2	15,9
781225	103,2	20,2	3,4	6,8
62258	38,2	21,4	2	10,5
73293	111,6	58,0	4	38,7
A9E0113	66,4	18,8	3	9,8
B0E0056B	37,8	15,9	2	10,0
Minimum	24,8	7,1	2	3,5
Maximum	125,2	64,1	4	44,6
Mean	58,3	25,1	2,6	14,4
StE	4,3	1,8	0,1	1,4
CV, %	54,18	53,6	21,2	73,7

Table 2. Morphological traits of 55 accessions of common bean - Continued

Cat.№	h 1st pod (cm)	Nr of pods/pl	Weight of pods/pl (g)	Pod length (cm)	Pod width (mm)	Pod tickness (mm)
A7E0269	13,4	7,8	9,9	10,5	1,0	0,8
A7E0268	10	4,8	7,1	11,4	1,2	0,6
A7E0270	13,4	5,2	5,7	9,1	0,9	0,8
A7E0292	11,8	4,4	5,7	10,5	0,7	0,6
A8E0271	19,6	4,4	5,5	8,7	0,8	0,6
A8E0634	10,2	5,6	8,5	10,7	1,2	1,0
A8E0543	10,8	4,4	3,9	7,7	0,9	0,6
A8E0646	9,6	9,4	15,3	10,1	1,2	0,7
A8E0641	12,4	12	16,1	7,9	0,9	0,7
A8E0458	12,2	6	5,8	7,5	1,0	0,7
A8E0439	12,4	5,6	7,8	9,5	0,9	0,7
A9E1426	9,4	5,6	5,2	7,6	0,8	0,5
A9E1123	12	4	6,8	9,8	1	0,6
A9E0708	14,8	4,6	4,1	7,8	0,8	0,7
A9E0639	7,8	3,6	3,4	6,7	0,7	0,6
786091B	9	7	9,8	9,8	0,9	0,8
A9E0449	11,4	9	11,9	9,7	1,0	0,6
A9E0405	10	7,2	8,8	9,5	0,9	0,8
A9E0311	11,0	5,7	8,1	11,4	0,8	0,5
A9E0608	8,2	15,6	22,6	9,6	0,8	0,7
B0E0056 A	10,6	8	12,8	10,9	0,9	0,7
A9E0587	14	8,4	14,1	10,5	0,9	0,8
A9E0182	20,4	10,8	23,4	11,8	1,4	0,8
78E6149A	8,2	4,4	6,9	11,4	0,8	0,9
A9E0139	9,2	6	7,5	10,7	0,8	0,8
A9E1121	10	7,8	15,9	8,9	1,2	0,9
C0E0308	12,4	9,8	6,8	9,5	0,7	0,5
A9E1008	16,6	6	8,1	11,5	0,9	0,7
A4E0001	9,2	5	7,7	11,0	0,9	0,5
A7E0668	12	8,2	9,2	9,5	0,9	0,5
A7E0137	17	4,2	4,2	9,0	1,0	0,6
811355	14	7	5,9	9,8	0,6	0,6
741356	9	13,4	13,4	8,1	0,7	0,6
B9E0001	18,4	15,2	14,6	8,7	0,6	0,5
B0E0054	15,2	5,8	11,2	10,6	1,4	0,8
B0E0048	9,2	8,2	9,3	8,7	0,6	0,6
741261	13	20,0	17,3	7,4	0,7	0,6
771174	10,8	3,6	5	10,0	0,7	0,6
811365	18,6	7,2	5,9	9,5	0,7	0,6
801331	8,8	14,4	14,0	14,1	0,9	0,6
771494	10,2	10,8	16,9	11,6	1,1	0,8
66720	7,8	10,2	16,7	11,8	0,9	0,6
781230	9,8	15,6	15,2	9,8	0,8	0,6
B1E0520	11,8	8,2	10,8	9,8	1,1	0,8

Cat.№	h 1st pod (cm)	Nr of pods/pl	Weight of pods/pl (g)	Pod length (cm)	Pod width (mm)	Pod tickness (mm)
B1E0536	6,6	6,8	7,9	9,9	0,7	0,6
B7E0212	14,2	8,4	13,8	9,9	1,1	0,9
761162	7,6	8,4	8,0	7,0	0,8	0,5
78E6781A	10	12	15,0	10,7	0,8	0,5
761376	7,8	11,8	9,8	6,9	1,1	0,7
771173	8,8	6,8	6,1	9,1	0,9	0,6
781225	13	9,8	12,8	8,0	1,1	0,8
62258	9,6	10,8	10,0	8,0	0,8	0,5
73293	10,2	12,8	17,6	8,0	1,8	0,5
A9E0113	11,6	8,2	8,2	8,9	1,0	0,7
B0E0056B	8,2	4,6	5,5	7,7	0,8	0,7
Minimum	6,6	3,6	3,4	6,7	0,6	0,5
Maximum	20,4	20	23,4	14,1	1,8	1,0
Mean	11,5	8,2	10,2	9,5	0,9	0,7
StE	0,4	0,5	0,6	0,2	0,0	0,0
CV, %	27,6	44,1	46,6	15,8	23,8	18,8

Seed morphology was characterized with seed length (SL), seed width (SW) and seed thickness (ST). Most of accessions formed seeds seed length > 1 mm and seed width >0.7mm. The accession with cat.No B7E0212 formed the longest seed with 1.76 mm and seed width 0.86 mm. The mean value of seed length among the studied accessions were 1.1 and seed width 0.7. Seed size was presented with 100 seed weight (g) where accession No 73293 showed the biggest seeds with 44.47 g of 100 seeds and two accessions No B7E0212 and No A9E1121 showed >39 g of 100 seeds weight. Seed morphology is characterized with less variation (Table 3) with CV -17.4% (SL) and CV-15.5% (SW) and higher coefficient of variation of seed size, compared with the previous seeds' traits with CV (100 SW) - 26%.

Table 3. Seed morphology

Cat.№	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Weight of 100 seeds (g)
A7E0269	1,06	0,58	0,5	29,8
A7E0268	1,36	0,76	0,5	30,3
A7E0270	1,18	0,78	0,56	34,1
A7E0292	1,18	0,5	0,4	28,45
A8E0271	0,96	0,76	0,5	22,7
A8E0634	1,26	0,76	0,5	35,48
A8E0543	1,24	0,74	0,5	35,4
A8E0646	1,04	0,74	0,54	37,84
A8E0641	1,08	0,68	0,5	25,84
A8E0458	1,16	0,66	0,5	28,54
A8E0439	1,14	0,7	0,488	31,974
A9E1426	1,06	0,56	0,46	33,72
A9E1123	1,3	0,7	0,5	27,7
A9E0708	1,04	0,76	0,56	31,43
A9E0639	0,84	0,54	0,5	20,06
786091B	1,1	0,7	0,5	21,4
A9E0449	1,26	0,66	0,5	30,14
A9E0405	0,9	0,74	0,58	26
A9E0311	1,17	0,6	0,5	23,73
A9E0608	1,06	0,56	0,46	37,6
B0E0056 A	1,3	0,62	0,52	35,5
A9E0587	1,3	0,68	0,58	38,87
A9E0182	1,1	0,74	0,58	34,92
78E6149A	1,34	0,58	0,5	30,27
A9E0139	1,1	0,7	0,58	28,63
A9E1121	1,06	0,76	0,66	39,34
C0E0308	1,06	0,46	0,4	16,31
A9E1008	1,26	0,66	0,46	23,59
A4E0001	1,34	0,68	0,48	29,38
A7E0668	1,34	0,68	0,48	28,9
A7E0137	1,24	0,66	0,48	33,87
811355	0,88	0,56	0,48	15,28
741356	0,86	0,48	0,48	16,8
B9E0001	0,86	0,46	0,46	20,9
B0E0054	1,16	0,66	0,56	30,55
B0E0048	0,9	0,52	0,48	19,2
741261	0,8	0,58	0,5	28,9
771174	1,2	0,6	0,5	21,47
811365	0,86	0,56	0,48	13,2
801331	1,06	0,56	0,5	23,06
771494	1,56	0,76	0,56	33,42
66720	1,24	0,74	0,5	33,6
781230	1,06	0,56	0,46	16,41
B1E0520	1,52	0,72	0,56	27,4
B1E0536	1,12	0,64	0,52	25,4
B7E0212	1,76	0,86	0,58	39
761162	0,88	0,58	0,5	23,3
78E6781A	1,24	0,64	0,5	28,2
761376	1,04	0,64	0,54	17,76
771173	1,26	0,56	0,46	15,78
781225	0,86	0,76	0,5	23,8
62258	1,04	0,64	0,48	19,81
73293	1,56	0,96	0,5	44,47
A9E0113	1,26	0,76	0,56	25,47
B0E0056B	1,16	0,56	0,46	27
Minimum	0,8	0,46	0,4	13,2

Cat.№	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Weight of 100 seeds (g)
Maximum	1,76	0,96	0,66	44,47
Mean	1,1	0,7	0,5	27,7
CV, %	17,4	15,5	9,1	26,0

Seed shape and seed color are of main importance for consumers (Sinkovič et al., 2019). Seeds showed predominantly cuboid shape and white color, however there is a diversity in seed shape with round, oval and kidney seeds with beige, brown and mottle seeds (Figures 2, 3, 4).

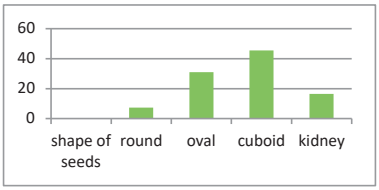

Figure 2. Seed shape

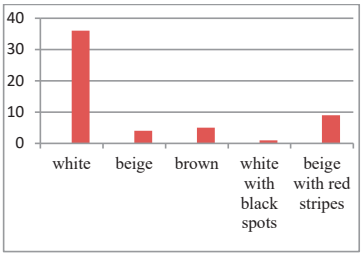

Figure 3. Seed color

Figure 4. Diversity of *Phaseolus* seeds

Cluster analysis

Clustering *Phaseolus vulgaris* accessions based on morphological traits showed four major groups. Cluster one contains 24 accessions, cluster 2 contains 7 accessions, while cluster 3 and 4 contain 12 accessions each (Figure 5). The dendrogram showed clusters of accessions formed mainly on their origin. Genetically narrow accessions were shown by the coefficient of similarities, as follows: accession No 1 (A7E0269) with No 2 (A7E0268) and accession No 4 (A7E0292) with No 29 (A4E0001). According to the coefficients of similarities accessions with maximum genetic distance were No 53(73293) and No 39 (813965), No 22 (A9E0587) and No 39 (813965), No 16 (786091B) and No 53 (73293).

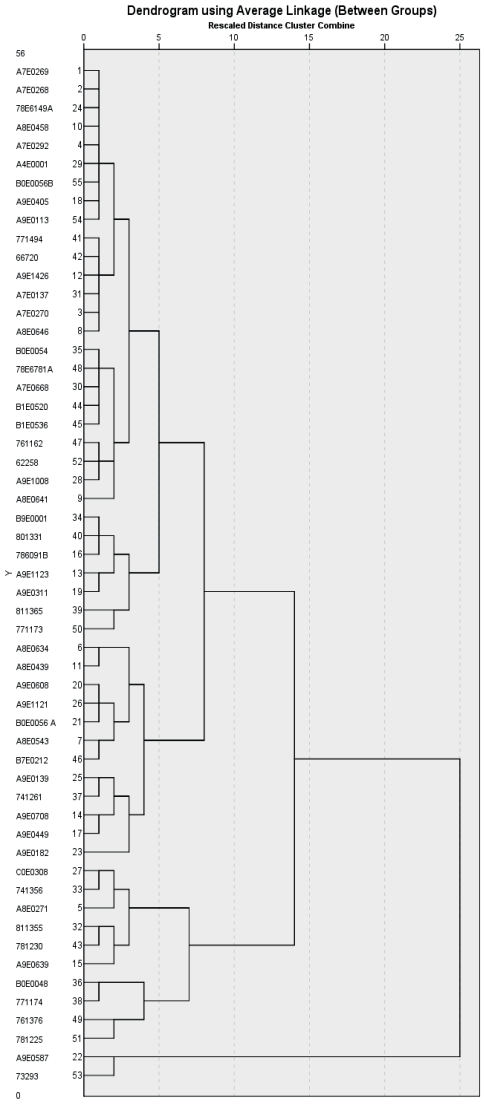

Fig. 5. Dendrogram illustrating similarities among 55 *Ph. vulgaris* accessions with local origin

During the experimental period evaluation on diseases resistance, common bacterial blight (*Xanthomonas axonopodis pv. phaseoli*) and hallo blight (*Pseudomonas syringae pv. phaseolicola*) were performed under fioeld conditions. Observations were done twice, during flowering and podding stages, using the scale from 1 to 9 (Bioversity 1982; Kiryakov & Genchev 2005).

Most of studied accessions didn't show symptoms of the two bacterial diseases (63.6%). Some of accessions showed medium resistance with 3-5 score 32.7%, while 3.6% showed sensitive reaction with evaluation of 7 scores.

The results were on the second observation, in middle of July, during experimental period. It is important to mention that from May to July there were unfavorable meteorological conditions with less quantity of rainfall than normal and it didn't allow the development of pathogens 'symptoms.

CONCLUSIONS

Quantitative traits have been used to study morphological diversity and important agronomic traits of *Ph. vulgaris* accessions with Bulgarian origin. Accessions with cat. No A7E0668 and B9E0001 were the earliest matured, while accessions cat. No 811355, cat. No 741356, cat. No 761376, cat. No 62258 needed 98 days to reach maturity.

Morphological traits, h of plant, weight of plant and weight of plant/without pods were with highest value of coefficient of variation. Accessions with cat. No A8E0641, A9E0311, A9E0182, 771174, 801331, B7E0212, 761376, 73293 were with the biggest vegetative mass of plant and showed biggest weight of plant without pods.

Diversity of seeds expressed by seed shape, seed color, and seed size was noticed with different shapes, diverse color of seeds and predominantly with medium seed size. Accession No 73293 showed the biggest seeds with 44.47 g of 100 seeds.

Evaluation on diseases resistance, common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*) and hallo blight (*Pseudomonas syringae pv. phaseolicola*), 32.7% of accessions showed medium resistance to the pathogens (3-5 score).

The results from this study could be used from breeders and researchers for different purposes of bean improvement. Evaluation of diseases resistance will help to select accessions with better performance under field conditions.

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