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MORPHOLOGICAL AND AGRO-BIOLOGICAL CHARACTERIZATION OF LOCAL AND INTRODUCED GERMPLASM OF COMMON BEANS (*PHASEOLUS VULGARIS* L.).

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Abstract

Phaseolus germplasm collection has a considerable potential value which can be widely used in breeding work as well as for direct use by farmers. The objective of the present research was to make morphological, agro-biological and agronomic characteristics of local and foreign accessions in order to select those with desirable traits. The study was carried out during the period 2021-2023 with 35 accessions of common bean (Ph. vulgaris L.). The accessions were with maturity from 84 to 98, with mean value of 88.5 days. Six accessions were the earliest with 84 days, while the latest were with maturation of 98 days. Two accessions showed higher grain yield from one plant (C1E0076, 93201018) with 17.8 and 18.9 g, respectively. Bigger variation was registered in weight of plant without pods and weight of plant, as well as number of pods and weight of seeds per one plant with coefficient of variation (CV%) 94.8, 57.0, 51.2 and 44.5%, respectively. The promising accessions will be selected as the most perspective with a view of their future utilization in the breeding process.

Key words*: common bean, origin, germplasm, characterization, evaluation.*

INTRODUCTION

Among pulse crops dry beans (*Phaseolus vulgaris* L.) are one of the most important grain legumes. Common bean is cultivated in the tropics and the temperate zones and in many regions it is considered staple food (Adikshita & Kansak, 2017). *Phaseolus* sp. had been found a favorable climatic conditions and it is established a big *Phaseolus* diversity over the country with different morphological, agro-biological and agronomic traits (Genchev & Kiryakov, 2005). Common bean is a traditional crop for Bulgarian population and it is often grown in crop rotation with cereals because of nitrogen fixing fertilization and its consequence to the next crop (Zheng, 1995). Local varieties and populations are result of plant evolution with farmers' participatory selection and local agro-climatic conditions (Santalla et al., 1999; Miles, 2002). Challenges of climate change put bean plants in difficult conditions with extreme high temperatures and low rainfall during flowering and pod formation stages. The common bean varies morphologically in growth habit, plant height, number of pods per plants, weight of seeds per plant, weight of 100 seeds and seed characteristics. Phenotypic and genotypic characterization provides useful information for better utilization of germplasm collection. The farmers use these characteristics to distinguish their varieties and give them names (Mekbib, 2007; Loko et al., 2018). Genetic variation in bean's landraces is considerably high and has the most diverse population of cultivated crops (Frankel et al., 1995; Qualset et al., 1997). Landraces are a repository of valuable gene pool, local adaptation of domestic species, and further more are a great source of genetic variation which can be used for genetic improvement and future breeding activities (Nawaz et al., 2022). Because of the effect of climate change, old age of the farmers and depopulations of the territories there is a risk of extinction of local plant materials. *Ex situ* conservation in genebank protect the loss of agro-biodiversity and to maintain the genetic variation in response to environment conditions and crop management (Gomes et al., 2013). Bean landraces are shown wide genetic base with diverse reaction to abiotic and biotic stress factors, compared with modern bred cultivars with narrowed genetic base and more sensitive reaction to environmental challenges. In mung bean gene of bruchid-resistance has been

successfully transferred to the cultivated genotypes from wild mung beans (Zhu et al., 2012; Chen et al., 2015). The common bean collection preserved in the National genebank at the Institute of Plant Genetic Resources (IPGR) consist over 2200 accessions with local and foreign origin and this collection continue increasing number of accessions (Stoilova et al., 2014). At about 1/3 of the collection had local origin, while the rest of the accessions originated from different parts of the world. Scientific work on *Phaseolus* germplasm started in 1903 from the beginning of the Experimental station (Ann. Rep., 1904). Common bean germplasm differ according to the origin, specific production and life activities of the people (Long et al., 2020).
The objective of the present research was to make agro-biological and agronomic characterization of the accessions and their morphological traits with a view of their future utilization in the breeding process for bean improvement.

MATERIALS AND METHODS

The study took place from 2021 to 2023. Thirty five accessions with different geographical origin were characterized and evaluated in the experimental field of IPGR, Sadovo, Bulgaria (Table 1). Every accession was sown in two row plots and in two replications in a randomized complete block design. In each plot, 10 plants per replication were randomly chosen for biometric measurements. Observations were made for 16 morphological characters: 1) days to initial flowering, 2) days to mass flowering, 3) flowering duration, 4) days to maturity, 5) plant height, 6) weight of plant, 7) number of branches, (8) weight of plant without pods, 9) height of 1st pod, 10) number of pods/plant, 11) weight of pods per plant, 12) pod length, 13) pod width, 14) number of seeds per pod, 15) weight of seeds per plant, 16) weight of 100 seeds. Morphological observations were made on seeds, color and shape. The morphological characterization was done according to Phaseolus descriptors (Bioversity/IBPGR, 1983). Duncan's New Multiple Range Test (DNMRT) was used for mean separation. All data analyses were performed using Data collected in field trials were analysed by SPSS 19 (Core System User's Guide. 697).

Table 1. Bean accessions included in this study

No in row	Cat. No	Origin	No in row	Cat. No	Origin
1	88201014	Bulgaria (BG)	19	A9E0658	BG Devene vill.
2	88201009	Bulgaria	20	786091B	Bulgaria
3	B2E0282	China	21	97E0003	Bulgaria
4	B2E0283	China	22	A9E1054	BG (Radomir)
5	B2E0285	China	23	B0E0040	BG (Dimitrovgrad)
6	C1E0075	Egypt	24	A7E0156	BG (Trigrad)
7	C1E0076	Egypt	25	B9E0059	BG (Indge Voivoda)
8	94201001	Netherlands	26	B9E0009	BG (Petkovo vil.)
9	94201002	Netherlands	27	A7E0752	BG (Dubrovnitsa)
10	91210121	Spain	28	A8E0359	BG (Kableshkovo)
11	93201020	Hungary	29	78E6089	Bulgaria
12	91201182	Colombia (CIAT)	30	90 E0279	BG (Slavyanovo)
13	93201018	Hungary	31	90 E0305	BG (Lyatno vil.)
14	95201017	USA	32	90 E0128	BG (Lom)
15	B7E0208	Greece	33	B1E0480	BG (Velingrad)
16	A8E0514	BG (Ivailovgrad)	34	B1E0479	BG (Velingrad)
17	A8E0594	BG (Burgas)	35	C2E0034	BG (Krichim)
18	A9E1085	BG (Haskovo)			

RESULTS AND DISCUSSIONS

Six accessions, three with local and three with foreign origin (94201001, 93201020, 91201182, 786091B, B9E0009 and C2E0034) started initial flowering 47 days after emergency and entered in the mass flowering phase after 56 days (Figure 1).

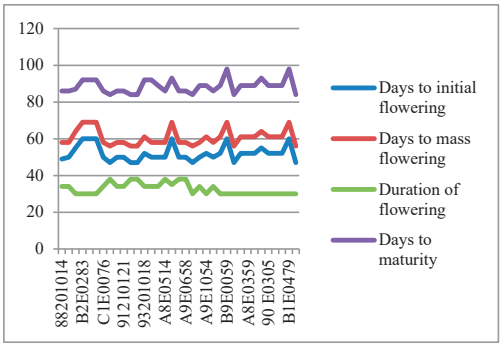

Figure 1. Phenological observations on 35 *Phaseolus* accessions

The earliest accessions matured after 84 days. Duration of flowering ranged from 30 to 38 days with mean value of 32.7 days. Accessions with foreign origin started mass flowering 58-61 days after emergency and matured for 84-92 days, while five accessions with local origin (B2E0283, B2E0285, C1E0075, A8E0594, B9E0059 and B1E0479) entered in full flowering stage after 69 days and reached

maturity in 92-98 days (Table 2). The difference of 47 and 69 days between the longest and shortest days to flowering and between 84 to 98 days to maturity showed a big variability in phenological phases among the all genotypes. This is in agreement with the results found by Fahad et al. (2014). Coefficient of variation (CV %) for the observed phenological stages were from 4.2% (days to maturity) to 9.4% (duration of flowering) (Table 2). The coefficient of variation (CV %) for days to initial and mass flowering were 8.2 and 7.2%.

Table 2. Minimum, maximum, mean and CV (%) values of phenological characteristics

Statistical values	Days to initial flowering (number)	Days to mass flowering (number)	Duration of flowering (number)	Days to 95% maturity (number)
Minimum	47	56	30	84
Maximum	60	69	38	98
Mean	52.1	60.7	32.7	88.5
St. Dev.	4.3	4.4	3.1	3.7
St. Error	0.7	0.7	0.5	0.6
CV%	8.2	7.2	9.4	4.2

Fifteen accessions were with indeterminate growth habit with plant height more than 75 cm. The maturation cycle of these accessions was 89-98 days with 5-10 days longer compared with accessions having determinate growth habit. The phenological differences exist because of genetically differences from each other which is in confirmation with reported results of 90 genotypes collected in Tanzania (Triphone & Nchimbi-Msolla, 2010).

Plant morphological traits (height of plant; weight of plant; number of branches; weight of plant without pods; height of 1st pod; number of pods /pl; weight of pods/plant) are shown in Table 3. Most of genotypes possessed determinate growth habit, which presented 57% of the total, 14.3% were with semi-climbing and 28.7% climbing growth habit. The tallest genotypes were predominantly with local origin with maximum value of the trait of 126.6 cm. The mean value of plant height was 69.5 cm with coefficient of variation (CV %) of 48.4%. Plants with taller stem (semi-climbing or climbing growth habit) showed potential for longer period of flowering and bigger seed yield. Tar'an et al. (2002) revealed positive correlations between components of plant height with time to flowering (FT) and rate of seed production. The most variable traits were, weight of plant and weight of plant without pods (with highest coefficient of variation CV-57% and 94.8%, respectively. Weight of plant differred among all accessions. The biggest value of weight of plant belonged to accession B9E0059 with 93.1 g the genotype with the least weight of plant was shown by accession C1E0075 with 12.2 g and mean value of the group was 30.6 g. In general phenotypic variation for agronomic traits ranged from 23.8 to 94.8% coefficient of variation (CV). Similar, high phenotypic variability of plant height and biological yield of 33 varieties and breeding lines was reported by Yohannes et al. (2020)

Table 3. Morphological characteristics of 35 bean accessions

Cat. No	h на p-e (cm)	Weight of plant (g)	Number of branches	Weight of plant without pods (g)	h 1st pod (cm)	Number of pods/pl.	Weight of pods/pl (g)
88201014	125,6	20,1	3,4	9,1	13,4	7,4	10,1
88201009	99,4	43,8	2,8	28,0	12,2	8,6	14,7
B2E0282	75,0	48,7	3,0	45,1	25,0	4,0	3,7
B2E0283	70,0	38,9	2,0	32,8	20,0	7,0	5,9
B2E0285	105,0	24,5	3,0	15,3	25,0	4,0	7,2
C1E0075	35,8	12,2	2,0	3,6	20,6	5,6	8,5
C1E0076	27,8	43,9	2,0	19,1	13,6	17,0	24,6
94201001	29,6	16,7	2,6	6,1	5,8	7,4	10,6
94201002	32,0	21,0	2,5	6,7	6,2	8,4	14,1
91210121	74,2	26,8	2,0	13,1	6,2	20,0	13,7
93201020	68,0	23,1	2,0	6,0	8,0	15,6	17,1
91201182	31,0	16,9	2,6	4,1	8,0	11,2	12,7
93201018	76,0	39,1	2,4	12,8	11,0	25,8	26,3
95201017	35,0	14,7	2,0	3,4	7,0	16,6	11,3
B7E0208	62,8	19,6	3,0	8,4	9,6	8,4	11,0
A8E0514	96,8	17,0	3,4	7,7	17,0	5,8	8,7
A8E0594	102,8	29,7	3,0	17,3	9,8	8,4	11,8
A9E1085	96,5	48,6	3,0	32,9	15,3	9,0	15,1
A9E0658	38,6	19,9	2,4	7,8	10,2	7,4	11,3
786091B	39,0	15,3	2,0	5,2	9,0	7,0	9,8
97E0003	35,6	20,5	2,0	12,2	9,8	6,0	7,7
A9E1054	38,2	30,0	2,2	15,1	11,6	10,4	14,0
B0E0040	62,4	15,8	3,4	8,4	14,4	5,8	6,5
A7E0156	39,6	21,0	2,8	14,4	15,4	7,0	6,8
B9E0059	121,0	93,1	4,0	82,2	11,3	6,7	9,9
B9E0009	122,4	75,1	4,0	66,1	13,4	5,4	8,4
A7E0752	29,6	29,9	3,0	12,7	11,6	13,2	15,8
A8E0359	126,6	32,8	4,0	25,4	12,4	5,4	7,0
78E6089	101,0	32,1	4,0	15,0	8,2	12,2	16,9
90 E0279	101,0	50,9	2,6	37,1	23,6	7,2	13,2
90 E0305	67,4	39,3	3,0	27,9	16,0	8,6	11,1
90 E0128	116,6	13,6	4,0	6,0	15,4	8,0	6,9
B1E0480	31,0	22,5	2,2	8,9	10,6	5,4	12,8
B1E0479	39,3	20,5	3,0	12,3	13,0	8,0	7,1
C2E0034	81,0	34,1	3,2	15,0	21,2	13,0	18,4
Min.	27,8	12,2	2,0	3,4	5,8	4,0	3,7
Max.	126,6	93,1	4,0	82,2	25,0	25,8	26,3
Mean	69,5	30,6	2,8	18,4	13,2	9,3	11,7
St. error	5,7	2,9	0,1	2,9	0,9	0,8	0,8
CV%	48,4	57,0	23,8	94,8	40,0	51,2	42,1

Seed yield is determined mainly by number of seeds per pod and seed weight per plant. In this study pod and seed size are presented in Table 4. The pod length varied between 6.4 and 13.7 cm, the biggest pod length belonged to accession A9E1085 and the least length of pod was mesured in B2E0282, both with local origin. The mean value of pod length was 9.6 cm with coefficient of variation (CV %) -17%. Pod width showed bigger variability compared with pod length with coefficient of variation (CV %) 22.5%.

Table 4. Pod and seed morphological traits

Cat. No	Pod length (cm)	Pod width (mm/cm)	Nr of seeds/pod	Seed length (mm)	Weight of seeds/pl (g)	Weight of 100 seeds (g)
88201014	7,9	1,1	4,6	0,9	7,5	30,4
88201009	10,3	0,9	3,8	1,2	9,4	31,4
B2E0282	6,4	1,8	2,0	1,2	1,2	26,3
B2E0283	6,7	0,7	3,0	0,9	3,3	26,3
B2E0285	9,0	1,4	3,0	1,2	5,0	28,9
C1E0075	9,0	1,0	3,2	1,3	6,5	33,0
C1E0076	10,7	0,9	5,8	1,0	17,8	39,5
94201001	8,7	1,2	3,2	1,2	7,5	38,0
94201002	8,6	1,4	3,2	1,5	9,7	61,0
91210121	9,1	0,8	4,5	1,2	9,4	22,7
93201020	9,5	1,2	3,6	1,4	11,7	37,2
91201182	11,2	0,8	3,8	1,5	8,6	45,0
93201018	8,7	1,2	3,4	1,4	18,9	33,5
95201017	6,8	0,9	4,0	0,9	9,1	17,9
B7E0208	9,8	1,0	4,6	1,2	8,5	29,3
A8E0514	10,1	1,0	3,8	1,1	6,3	33,9
A8E0594	9,3	0,7	4,4	1,1	8,0	33,1
A9E1085	13,7	1,1	4,8	1,4	10,5	23,2
A9E0658	11,5	1,2	7,2	1,1	7,5	33,2
786091B	9,8	0,9	5,0	1,1	6,6	21,4
97E0003	12,4	1,0	3,4	1,3	5,1	23,6
A9E1054	13,4	0,8	4,4	1,5	8,0	24,7
B0E0040	9,8	0,8	4,6	1,2	4,7	23,4
A7E0156	8,8	0,9	4,6	1,2	4,3	32,9
B9E0059	10,6	0,9	3,7	1,5	7,6	38,2
B9E0009	8,6	1,0	2,4	1,6	6,0	50,5
A7E0752	8,9	0,9	4,6	1,2	11,9	31,4
A8E0359	10,3	1,0	3,8	1,3	4,6	31,5
78E6089	9,7	1,0	6,4	1,0	11,2	24,5
90 E0279	8,0	0,7	4,4	1,0	10,3	21,1
90 E0305	9,0	0,8	4,6	1,2	8,2	26,9
90 E0128	10,2	0,9	4,6	1,1	5,1	24,4
B1E0480	10,4	0,9	4,4	1,1	8,8	31,6
B1E0479	9,0	1,0	5,3	1,1	4,8	26,8
C2E0034	8,6	0,9	4,6	1,2	13,4	34,0
Min.	6,4	0,7	2,0	0,9	1,2	17,9
Max.	13,7	1,8	7,2	1,6	18,9	61,0
Mean	9,6	1,0	4,2	1,2	8,2	31,2
St. Error	0,3	0,0	0,2	0,0	0,6	1,5
CV%	17,0	22,5	24,8	14,9	44,5	27,8

There were accessions with 0.7 mm (minimum) and with 1.8 cm (maximum). Number of seeds per pod varied between 2 to 7.2 with mean value of 4.2. Coefficient of variation was (CV%) 24.8%. Accessions with bigger number of seeds per pod were A9E0658 (7.2), 78E6089 (6.4), C1E0076 (5.8) with local origin. The seeds per pod in introduced common bean accessions were from 3.2 (94201001) to 4.6 (88201014). The positive correlation of grain yield with number of seed/pod and plant height was reported by Kamaludin and Ahmed (2011). The highest weight of 100 seeds were found by the genotype 94201002 with 61 g, followed by B9E009 (50.5 g) and 91201182 (45 g).

The plant height among all genotypes was divided in three statistical groups, low, moderate and hight plant height with level of sigificance at $P \leq 0.005$. First group contained 12 accessions of common bean with the shortest plants ranged between 29.6 and 39 cm (34.3%) (Table 5). The accessions with plant height situated in the medium group ranged between 39.6 and 77.8 cm (22.8%). The group with genotypes showed the highest plant height was formed by the four genotypes ranged between 119.6 and 126.6 cm (11.4%). There is a subgroup between medium and the highest plant height consisted by 11 genotypes with ranged of plant height from 81 to 116.6 cm (31.4%). Results showed five statistical groups among genotypes according to the height of the first pod (Table 5). The lowest pod was found in a group of eleven genotypes with pods located between 8.2 to 9.8 cm distance from the soil surface (31.4%). The highest pod was situated at 24.6 cm height from the soil. There were three subgroups, medium with ten accessions ranged from 10.6 to 13.4 cm, medium to high with two genotypes and the third subgroup with highest distance consisted of 7 genotypes (20%). According to the number of pods per plant genotypes showed three stitistical groups with significant differences. Accessions with the least number of pods per plant were 8 genotypes (22.8%), ranged from 4 to 5.4 (Table 5).

The medium group contained 7 genotypes (20%) with 6.4 to 7.4 number of pods per plant. Two genotypes showed the biggest number of pods per plant with 19.2 and 23.6, respectively. There is a subgroup between medium and highest number of pods per plant contained of 15 genotypes (42.8%). There is not so big diversity among all genotypes in weight of seeds per plant. There were two statistical groups with significant differences. In the first group were

two genotypes with 17.7 and 17.8 g, while in the second group were 33 genotypes (94.3%) with high weight of seeds per plant, ranged from 4.3 to 13.4 g. Weight of 100 seeds was divided in 4 statistical groups, the group with the least weight contained 14 accessions (40%), while the other three groups contained 2 or 3 accessions.

Table 5. Diversity among all included genotypes on five morphpological traits

Cat. No	Height of plant	Height of 1st pod	Nr. of pods/pl.	Weight of seeds/plant	Weight of 100 seeds
88201014	125,6a	13,4cd	7,4b	7,54b	7,5c
88201009	99,4ab	12,2cd	8,6ab	9,4b	9,4c
B2E0282	75,4b	24,6a	4,4c	1,61b	1,6d
B2E0283	72,4b	20,8ab	6,6b	3,15b	3,2d
B2E0285	101,2ab	23,2ab	4c	5,1b	5,1dc
C1E0075	35,8c	20,6ab	5,6c	6,5b	6,5c
C1E0076	27,8c	13,6c	17ab	17,8a	17,8ab
94201001	30,5c	7,2e	6,6b	7,2b	7,2c
94201002	33c	8,6e	7,6ab	9,3b	9,3c
91201121	73b	8,2e	19,2a	9,4b	9,4bc
93201020	69b	9e	14,6ab	11,4b	11,4ab
91201182	31,4c	7,6e	10,6ab	8,4b	8,4c
93201018	77,8b	11,6cd	23,6a	17,7a	17,7ab
95201017	38c	7,4e	17,4ab	9,6b	9,6b
B7E0208	108,8ab	9,6e	8,4ab	8,5b	8,5c
A8E0514	96,8ab	17ab	5,8c	6,3b	6,3c
A8E0594	102,8ab	9,8e	8,4ab	8b	8c
A9E1085	93,2ab	15bc	9,2ab	10,6b	10,6ab
A9E0658	38,6c	10,2d	7,4b	7,5b	7,5c
786091B	39c	9,4e	7b	6,7b	6,7c
97 E 0003	35,6c	9,8e	6bc	5,1b	5,1dc
A9E1054	38,2c	11,6cd	10,4ab	8b	8c
BOE0040	88,4ab	14,4bc	5,8c	4,7b	4,7dc
A7E0156	39,6b	15,4b	7b	4,3b	4,3dc
B9E0059	119,6a	11,2cd	6,4b	7,8b	7,8c
A9E1085	122,4a	13,4cd	5,4c	6b	6c
A7E0752	29,6c	11,6cd	13,2ab	11,9b	11,9ab
A8E0359	126,6a	12,4cd	5,4c	4,6b	4,6dc
78E6089	101ab	8,2e	12,2ab	11,2b	11,2ab
90 E 0279	101ab	23,6ab	7,2b	10,3b	10,3b
90 E 0305	67,4b	16ab	8,6ab	8,2b	31a
90 E 0128	116,6ab	15,4b	8ab	5,1b	31,4a
B1E0480	31c	10,6cd	5,4c	8,8b	26,8ab
B1E0479	39,8b	13cd	7,8ab	5,1b	26,3ab
C2E0034	81ab	21,2ab	13ab	13,4b	29a

There was a big subgroup between medium and highest weight of 100 seeds contained of 8 genotypes (22.8%) (Table 5).

Seed traits are the most important in common beans especially for commercial acceptability of different varieties (Bisht et al., 2014). The seed traits have important role as they are considered highly heritable (Blair et al., 2010). A big diversity among all studied accessions was observed, ranging from single color to mottled and striped types with different tonalities. White seed color was in 45.7% followed by mottled beige with lilac (14.3%) and brown color (11.4%). The rest groups were with less than 10% (Figure 2). There is a diversity in seed shape with predominantly kidney and cuboid shape, consisted 48.6% and 45.7%, respectively (Figure 3). The most frequent shape and color of bean seeds were noticed as white with kidney or cuboid shape.

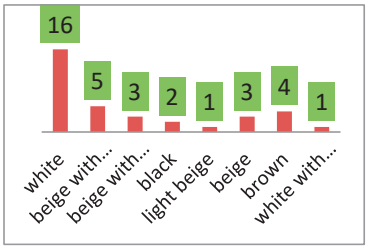

Figure 2. Seed color

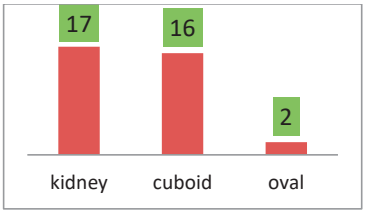

Figure 3. Seed shape

CONCLUSIONS

Morphological and agronomc traits were studied on a small sub set of Phaseolus vulgaris genotypes with local and foreign origin using qualitative traits. There is a diversity on the earliness of the genotypes, they can be divided as early, medium and late maturity. Accessions with cat. No 786091B and C2E0034 were the earliest with 84 days to maturity, while accessions with cat. No B1E0479 and B9E0059 were the latest with 98 days to reach maturity. Variability in morphological traits, plant height, heght of the 1 st pod, number of pods per plant, weight of seeds per plant and weight of 100 seeds were studied. Different statistical groups were established according to the variation of the trait inside the group of studied genotypes. The biggest diversity was found in the height of the first pod, followed by the weight of 100 seeds, plant height and weight of seeds per plant. The least variation was observed on the number of pods per plant. Accessions with cat. No B2E0282 and 90E0279 were with highest 1st

pod, accessions with cat. No 93201018 and 91201121 were with biggest number of pods per plant, while the biggest size of seeds were produced by the accessions with cat. No 90E0305 and C1E0034 with 31 and 29 g of 100 seeds. Diversity in seed color and shape was found with predominant white color and kidney shape.

The studied diversity among qualitative vegetative and reproductive traits can be used for breeding new varieties or for bean improvement.

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