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BIOLOGICAL POTENTIAL OF A COMMON BEAN COLLECTION IN RELATION WITH THE CLIMATE CHANGE

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Abstract

Common bean is a traditional grain legume crop in Bulgaria. It is mostly grown and used worldwide for its edible seeds. The genebank at IPGR-Sadovo preserves a large number and diverse collection of Phaseolus vulgaris L. Biotic and abiotic stress factors are causing significant yield and quality losses in common beans. The study aims to investigate accessions by biological, morphological, and agronomic traits and to select genotypes with diseases and drought resistance. For the current study, 26 accessions of local and foreign origin were used. Most of them are traditional varieties. The biometry and phenology analyses follow the Descriptors for Phaseolus vulgaris of IBPGR (1982). Observations on resistance to bacterial disease symptoms, caused by the pathogen, Xanthomonas campestris pv. Phaseoli were made using the CIAT scale (1987). The accessions were grown under nonirrigated conditions and the drought tolerance was recorded. The study gives valuable preliminary information for the common bean collection's biological potential about climate change. The investigation will be continued as a complex evaluation in the next experimental years.

Key words*: genebank, common bean, agro-climatic conditions, biometry, disease resistance.*

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) originates from Asia and the tropical regions of America. It is considered one of the oldest cultivated plants. American types of beans are commonly grown in Europe (Agricultural Academy, 1973).

The largest producers of beans in the world are India, Brazil, Mexico, and the European countries – Turkey, Romania, Italy and France (Ivanova et al., 2019). This species is an excellent precursor for almost all field crops because it enriches the soil with nitrogen.

The beans from *Phaseolus vulgaris* L. are mainly used for culinary purposes. Various traditional dishes are prepared from its seeds, such as purees, soups, stuffed peppers, etc. Both dry and green beans are used for canning. It is widely consumed in its green state when the vitamin C content is higher. Bean seeds are high in protein, fats, carbohydrates, minerals, B vitamin, and provitamin A (Ivanova et. al., 2019). Because of this, the quality of the seeds and pods is one of the important traits, which is also related to the resistance of the plants to drought and diseases.

Except for the common bean, there are many other traditional grain legume crops worldwide, and collecting plant germplasm is essential for saving biodiversity and its use in breeding and practice. Plant genetic resources are a national treasure that must be sustainably conserved and used (FAO, 2014).

The main priority of the scientific team of IPGR "K. Malkov" – Sadovo, part of the Agricultural Academy – Bulgaria, is the long-term storage of plant germplasm through seeds under controlled conditions in the National Genebank. IPGR-Sadovo is part of the European Program on Plant Genetic Resources (ECPGR, 2021) and the collection is published with open access in the European catalogue EURISCO (http://eurisco.ecpgr.org).

The yields of major agronomic crops are negatively impacted by climatic changes in several aspects as the intensity of rainfall, increasing the mean temperature, heat waves, changes in weeds, disease-causing microorganisms, and pest attacks during all growing seasons. Higher temperature frequently causes a reduction in crop yield because, they generally happen in combination with drought.

Crop phenology is negatively affected due to the climate change (Fatima et al., 2021).
The aim of the study is to investigate the collection by biological, morphological, and agronomic traits and to select accessions with diseases resistance and drought tolerance.

MATERIALS AND METHODS

The comparative experiment in the field of IPGR-Sadovo, Department of Plant Genetic Resources was conducted.
Twenty-six accessions, including 17 acc. with local Bulgarian origin (12 acc. determinant and 5 acc. indeterminate) and 9 acc. with diverse origin (USA – 1 acc.; Korea – 1 acc.; Germany – 2 acc.; Hungary – 1 acc.; Portugal – 1 acc.; Turkey – 1 acc.; Chilly – 2 acc.), from which 7 determinant and 2 indeterminate accession were planted (Table 1).
Each of the accessions was grown in two replications in two row plots with a length of 2 m.

Table 1. List of the accessions used for the study

N	Cat. N	Taxonomy	Growth habit	Origin
1	A9E1426	*Ph. vulgaris* L.	determinate	Local/BGR
2	A9E0639	*Ph. vulgaris* L.	determinate	Local/BGR
3	A9E0658	*Ph. vulgaris* L.	determinate	Local/BGR
4	A9E1101	*Ph. vulgaris* L.	determinate	Local/BGR
5	A7E0668	*Ph. vulgaris* L.	determinate	Local/BGR
6	C1E0039	*Ph. vulgaris* L.	determinate	Local/BGR
7	C2E0025	*Ph. vulgaris* L.	determinate	Local/BGR
8	C0E0310	*Ph. vulgaris* L.	determinate	Local/BGR
9	C4E0001	*Ph. vulgaris* L.	determinate	Local/BGR
10	C4E0002	*Ph. vulgaris* L.	determinate	Local/BGR
11	C4E0003	*Ph. vulgaris* L.	determinate	Local/BGR
12	C4E0004	*Ph. vulgaris* L.	determinate	Local/BGR
13	A9E0405	*Ph. vulgaris* L.	indeterminate	Local/BGR
14	A9E0608	*Ph. vulgaris* L.	indeterminate	Local/BGR
15	A9E0182	*Ph. vulgaris* L.	indeterminate	Local/BGR
16	A7E0137	*Ph. vulgaris* L.	indeterminate	Local/BGR
17	84201011	*Ph. vulgaris* L.	indeterminate	Local/BGR
18	91201180	*Ph. vulgaris* L.	determinate	USA
19	91201083	*Ph. vulgaris* L.	determinate	KOR
20	69886	*Ph. vulgaris* L.	determinate	DEU
21	91201122	*Ph. vulgaris* L.	determinate	DEU
22	771423	*Ph. vulgaris* L.	determinate	HUN
23	91201025	*Ph. vulgaris* L.	determinate	PRT
24	91201228	*Ph. vulgaris* L.	determinate	TUR
25	771427	*Ph. vulgaris* L.	indeterminate	CHL
26	771458	*Ph. vulgaris* L.	indeterminate	CHL

A conventional cultivation method was used, which included several treatments (manual and machine), as well as plant protection and fertilization of crops. All the accessions were grown under nonirrigated conditions. The agro-climatic conditions are monitored by a meteostation, located in the IPGR-Sadovo.
For the biometry and phenology observations, the Descriptors for *Phaseolus vulgaris* (IBPGR, 1982) was used.
Phenology measurements were carried out during the growing season of the crop, recoding the following phenology periods: days to germination – the days from sowing to the germination of 50% of the plants under the surface; days to flowering – number of days from germination to stage where 50% of plans have set flowers; duration of flowering – number of days from first flowers in 50% of the plants to the stage when 50% of the plants have stopped flowering; days to maturity – number of days from emergence until 90% of the pods are mature.
For the biometric analyses, 20 randomly chosen plants per replication. The biometry traits are: plant height; number of pods per plant; beans per pod; the weight of 1000 seeds; seed (length, width, and thickness); length of the pod; height of the first pod. An average sample of 20 pods and 20 seeds was taken and biometry was measured using Mitutoyo 500-196-30 Digimatic Absolute Caliper 150 mm. The weight of 1000 seeds was measured using a digital scale.
For evaluating the plant's reaction to drought, a scale of 1-3 was used for sensitivity to stress from the Descriptors for Phaseolus vulgaris (IBPGR, 1982), where 1 is slightly sensitive, 2 is medium sensitive, and 3 is highly sensitive for symptoms such as loss of turgor of the leaves, dry plants, etc.
Visual investigation of typical for the bacterial disease “common bacterial blight” symptoms was conducted. The severity of the symptoms was evaluated using a 1-9 scale, where 1 - no visual symptoms, 3 - symptoms are observed on 2% of the leaf blade surface; 5 - symptoms are observed on 5% of the leaf blade, diameter of the spots - 5 mm; 7 - symptoms are observed on 10% of the leaf blade, diameter of the spots - 10 mm; 9 - symptoms are observed on more than 25% of the leaf blade (CIAT, 1987; Genchev and Kiryakov, 2005).

The created characterization and evaluation database from the experiment was statistically processed using IBM SPSS Statistics 26 software and Analysis Tool Pak in MS Excel. The variation is considered as weak if the coefficient of variation (CV %) does not exceed – 0%, medium - the variation between 10-20%, and strong (significant) – when the variation is over 20% (Genchev et al., 1975; Dimova and Marinkov, 1999).

RESULTS AND DISCUSSIONS

The temperatures during the growing season were higher compared to the temperature norms for the region of Sadovo, Central South Bulgaria. In the experimental period, the maximum temperatures during the bean formation ranged from 33.7ºC to 36.4ºC (Figure 1). The minimum temperatures ranged from 8.7ºC in April to 18.4ºC in July.

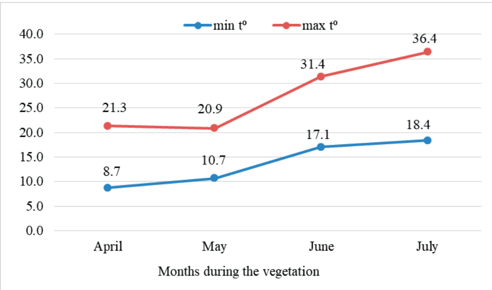

Figure 1. Min and Max temperature from sowing to harvesting of common bean

Precipitation is also one of the most important factors that determines the yield in our country. For the seed germination, it needs to absorb 80-145% water by weight (Ivanova et al., 2019). The sum of the fallen rains during the vegetation of the plants was 123.6 l/m^2. The highest quantity of rain was recorded in May during the plant's development (Figure 2). It has to be noted that most of the precipitation in May fell after the appearance of the first plants. Also, the amount of precipitation in June is scarce.

After the sowing date, the first sprouted plants were noted in May, which is quite a long period. The periods that are compared are presented in Table 2, where: days to germination – the days from sowing to the germination of 50% of the plants under the surface; days to flowering – the number of days from germination to stage where 50% of plans have set flowers; duration of flowering – number of days from first flowers in 50% of the plants to the stage when 50% of the plants have stopped flowering; days to maturity – number of days from germination until 90% of the pods are mature.

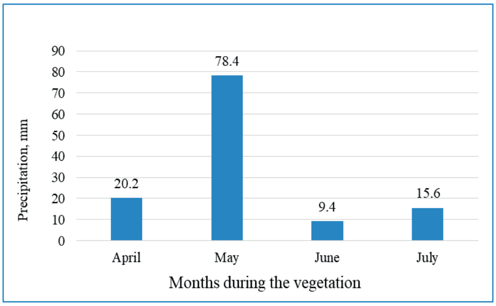

Figure 2. The sum of a precipitation by months from sowing to harvesting of common bean

The days of the germination period are noted for three accessions with longer periods (28 days): 91201122; 771423 and 771427 from the introduction. One day earlier A9E1101; C1E0039; C2E0025; C4E0002; C4E0004; A9E0182; 84201011; 91201180; 91201083; 771458 are germinated. With the shortest duration period of 25 days to germination are the accessions: A9E1426; A9E0639; A9E0658; A7E0668; C0E0310; C4E0001; C4E0003; A9E0405; A9E0608; A7E0137; 69886; 91201025 and 91201228. With the longest period to flowering is A9E0608 from the expedition and the earliest are C4E0004; 91201083; 91201122; and 771423. According to days to the duration of flowering, there are noted A9E0658; C4E0004 with 26 days and with the shortest duration (15 days) are A9E0608 and 771458. About the vegetation cycle could be said that with shortest period are 91201122 and 771427; with the longest period are 91201025 and 91201228. There is no big difference between the vegetation periods of the accessions. The variation is only between 5 days.

If we compare the close results in the duration of vegetation: the short vegetation period, the duration of flowering, and days to germination which is quite a short period too, it could be assumed that the high maximum temperatures and the fewer precipitations in the important stages of growing are negative factor for the common bean. The lack of rainfall under nonirrigated is considered critical. As a result, in these conditions, the vegetation of all accessions was recorded as delayed and late germination. The rains were scarce and the plants did not germinate uniformly (Photos 1 and 2).

In common beans (*Ph. vulgaris* L.) high temperatures affect negatively flowering, fruit setting, and maturity cycle, such as stress factors leading to the abortion of flowers and pods, and causing premature ripening of plants (Minoz-Perea et al., 2006).

Photos 1 and 2 – Germination of the studied collection

Table 2. Phenological data for the experiment

N	Cat. N	Days to germination	Days to flowering	Duration of flowering	Days to maturity
1	A9E1426	25	32	17	71
2	A9E0639	25	37	22	71
3	A9E0658	25	29	26	73
4	A9E1101	27	30	17	69
5	A7E0668	25	30	25	71
6	C1E0039	27	31	24	69
7	C2E0025	27	30	24	69
8	C0E0310	25	31	25	71
9	C4E0001	25	30	22	71
10	C4E0002	27	30	21	69
11	C4E0003	25	30	18	71
12	C4E0004	27	27	26	69
13	A9E0405	25	32	18	71
14	A9E0608	25	34	15	71
15	A9E0182	27	31	17	69
16	A7E0137	25	30	22	71
17	84201011	27	28	21	69
18	91201180	27	28	25	69
19	91201083	27	27	21	69
20	69886	25	30	22	70
21	91201122	28	27	22	68
22	771423	28	27	22	67
23	91201025	25	32	24	73
24	91201228	25	32	22	73
25	771427	28	31	22	68
26	771458	27	32	15	71

For characterizing the studied accessions biometric measurements were conducted (Table 3). Plant height and the height of the first pod are important traits for grain quality, whereas pods located in the upper part of the plant will avoid contact with the soil surface, which is a source of pathogens, according to Dianatmanesh et al. (2017).

In the studied group the average plant height is 38.45 cm. The accessions with the highest plants are: A9E0182; A9E0405 and A9E0405 but with lowest are 771423; 69886 and 771427. With the highest pod position are the accessions A9E1426 and C4E0002. Accessions with more beans per pod are: 771427; 91201228; 91201122; and C2E0025. The weight of 1000 seeds is an important trait and the mean from Table 3 is 200 g. With a maximum weight of 1000 seeds is distinguishes 91201180 of 255 g and A9E0182; A9E0405; C4E0001 follow him with around 240 g. The trait number of pods per plant is maximum presented in the accession 771458 from Chilly with the maximum number of pods per plant (9.00) and with a minimum is

C4E0004 (local variety pinto bean). The maximum length of the pod is cat. N 91201083. The traits of the seeds – length, width, and thickness are very variable. The mean scales for the seed sizes are: length - 1.12 cm, width - 0.64 cm, and thickness - 0.5 cm.

Table 3. Biometric measurements conducted for characterizing the studied accessions

N	Cat. N	Plant height, cm	Number of pods per plant	Beans per pod	Weight of 1000 seeds	Seed length	Seed width	Seed thickness	Length pod	Height of the 1st pod
1	A9E1426	39.80	3.50	3.00	195	1.18	0.61	0.50	7.50	23.50
2	A9E0639	31.30	2.50	2.60	105	0.82	0.60	0.46	6.00	16.20
3	A9E0658	44.80	3.00	2.60	190	0.87	0.69	0.48	7.20	180
4	A9E1101	30.40	4.70	2.60	225	1.22	0.79	0.58	8.20	16.20
5	A7E0668	31.40	3.60	2.00	165	1.07	0.64	0.47	6.40	16.00
6	C1E0039	34.10	2.00	2.00	205	0.96	0.65	0.62	9.10	14.30
7	C2E0025	36.50	6.00	4.00	195	0.98	0.69	0.50	8.10	20.40
8	C0E0310	39.60	4.00	2.50	155	1.14	0.56	0.52	7.70	17.70
9	C4E0001	34.00	3.80	2.60	240	1.28	0.61	0.48	9.60	20.50
10	C4E0002	42.60	2.30	2.00	220	1.22	0.68	0.49	7.50	23.50
11	C4E0003	36.20	2.60	2.40	195	1.09	0.73	0.46	6.50	20.20
12	C4E0004	34.80	1.50	3.00	205	0.97	0.63	0.45	8.70	19.10
13	A9E0405	57.70	3.80	3.00	245	0.95	0.76	0.49	6.50	15.60
14	A9E0608	47.70	2.00	1.30	155	1.17	0.69	0.53	6.70	21.00
15	A9E0182	60.80	3.00	2.80	245	1.13	0.56	0.54	7.10	22.5.
16	A7E0137	37.60	1.70	2.00	220	1.18	0.64	0.50	5.50	16.30
17	84201011	57.80	6.60	2.00	195	1.15	0.66	0.50	8.00	17.50
18	91201180	31.00	2.20	2.20	255	0.94	0.67	0.57	6.60	16.20
19	91201083	33.00	3.60	1.80	239	1.20	0.58	0.48	12.20	17.00
20	69886	27.00	3.70	3.50	187	1.05	0.60	0.53	9.30	12.50
21	91201122	31.50	3.00	4.20	146	1.04	0.55	0.40	7.50	15.30
22	771423	25.10	4.00	1.50	217	1.17	0.57	0.57	8.80	12.00
23	91201025	41.20	3.20	3.20	181	1.16	0.58	0.39	9.30	20.30
24	91201228	36.20	3.00	4.50	173	1.83	0.59	0.40	11.60	22.70
25	771427	28.70	5.50	4.30	213	1.26	0.62	0.50	7.70	12.00
26	771458	49.00	9.00	2.50	233	0.98	0.70	0.50	9.10	17.60
	Mean	38.45	3.61	2.70	200	1.12	0.64	0.50	8.02	17.85
	Min	25.10	1.50	1.30	105	0.82	0.55	0.39	5.50	12.00
	Max	60.80	9.00	4.50	255	1.83	0.79	0.62	12.2	23.5
	St. error	1.87	0.33	0.17	7.00	0.04	0.01	0.01	0.31	0.66
	St. deviation	9.55	1.67	0.85	35.72	0.19	0.06	0.06	1.59	3.36
	CV %	24.84	46.26	31.48	17.86	16.96	9.38	12.00	19.83	18.82

The coefficient of variation (CV %) is an important statistical feature that makes it possible to establish the relative alignment of the variation among the studied group. It is also important to know how much the studied material is level or heterogeneous and the compared signs are variable. Taking into account the coefficient of variation, the variation is strongest in the following indicators: height of the plant, number of seeds per pod; pods per plant. The variation is medium in the weight of 1000 seeds; seed length; seed thickness; length of pod and height of the first pod. The variation was considered as low only for the trait seed width.

In the agro-climatic conditions the reaction of the plants to drought and diseases was studied. For the disease evaluation visually were monitored the symptoms on leaves typical for "common bacterial blight". Among the accessions with local origin that did not show symptoms of the infection are: C0E0310; C4E0001; C4E0002; C4E0003 and 84201011, and those of foreign origin are: 91201083 (KOR); 69886 (DEU); 91201122 (DEU); 771423 (HUN); 91201025 (PRT); 91201228 (TUR); 771427(CHL) and 771458 (CHL) (Figure 3).

As a result of this preliminary evaluation the local traditional varieties C0E0310, C4E0001, C4E0002, C4E0003 and the German 69886, showed good resistance to both stress factors – drought and the disease.

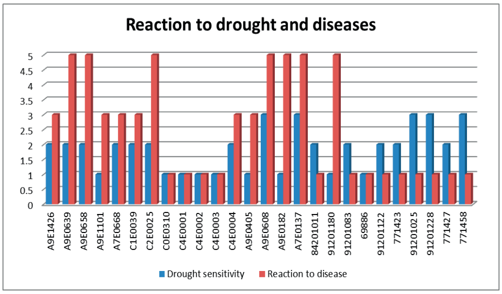

Figure 3. Reaction of the plants to drought and diseases

On the basis of all evaluated traits the accessions were classified by hierarchical cluster analyses using average linkage (Between groups) (Figure 4). According the dendogram the studied groups of accessions could be divided in 3 clusters. In all of them are grouped accessions with different origin. Similar results are presented from Stoilova et al. (2024). In the first cluster are grouped 14 accessions (from 1 to 14). In the second cluster are included 11 accessions (from 10 to 26). These genotypes are characterized with larger seeds compared to the accessions grouped in the cluster 1. As the most different from all accessions is the cat. N A9E0639 (2). This genotype is not grouped with other forms and is characterized with the smallest seeds and high sensitivity to drought and disease.

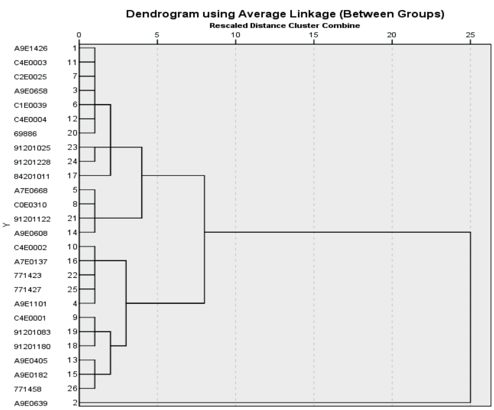

Figure 4. Dendogram of the clusterisation using Avarage Linkage (Between Groups)

CONCLUSIONS

As a result of this preliminary evaluation the local Bulgarian varieties C0E0310, C4E0001, C4E0002, C4E0003 and the German accession 69886, showed good resistance to both stress factors – drought and the disease.

According the analysis the studied collection could be divided in three clusters. In each of them the accessions are with diverse geographical origin.

The most different from all accessions is the local Bulgarian genotype A9E0639. It is characterized with the smallest seeds and high sensitivity to drought and disease and should be excluded from future breeding schemes aiming at resistance and good seed quality.

For further evaluation more precise experiments are needed.

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