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EVALUATION OF INDIGENOUS GRAIN LEGUME COLLECTIONS

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Abstract

Grain legumes have positive impact on global food and nutrition security. Grain legume collections, maintained at the Institute of Plant Genetic Resources - Sadovo are represented by 10 botanical genera. The aim of the current study is to evaluate the phenotypic diversity of local accessions from five grain legume collections (*Vicia faba, Pisum* sp., *Lathyrus* sp., *Cicer arietinum* and *Lupinus* sp.) and to select the best ones with potential to be used under different agro-climatic conditions. The assessment of morphological and agro-biological traits was performed according to the International Descriptor for each crop. The structural elements of the yield, such as the number of pods and the mass of pods and grains per plant, grains size, etc. have a significant impact on the productivity of the grain legumes. The variability of agronomic and biological traits has shown high genetic diversity in evaluated grain legume collections and increased the possibilities for their use in the breeding-improvement activity. Based on phenotyping assessment several grain legume accessions were distinguished as starting breeding materials: from pea collection - two cultivars and two local populations; from chickpea collection - four populations; from faba bean collection – eight populations; from bitter vetch collection – two accessions; from grass pea collection - six genotypes; from white lupin collection – two accessions. The study of the materials from the collections was focused on the interests of researchers, breeders and producers.

Key words: legumes collections, genetic diversity, agro-biological assessment.

INTRODUCTION

Grain legumes have a positive impact on the global food and nutrition security. However, due to biotic and abiotic challenges their production rate remains unsatisfying compared to their consumption rate (Ojiewo et al., 2018). Therefore, there is a need to look for sustainable alternative strategies to improve and diversify their production. The most popular with traditions of growing are common bean, pea, faba bean and soybean. The legumes like cowpea, lentils, vetch, bitter vetch, lupine, chickpea, grass pea are grown in a very small area in different parts of the country. The mature grains of the common bean, pea, chickpea, grass pea, faba bean, soy bean are used to make flour and fortified the wheat flour and increase the nutritional value of the products. The quality of bread and pasta with added legume flour has higher nutritional value than bread made from wheat or rye alone (Bojňanská et al., 2012; Magrini et al., 2019). The effects of 10% chickpea flour supplementation increased water absorption and stability of kneading, increased valorimetric value and the energy of dough deformation compared to the control (Petrova and Mangova, 2013).

Grain legume collections, maintained at the IRGR, are represented by 10 botanical genera: *Phaseolus sp., Vicia sp., Arachis sp., Pisum sp., Glycine sp., Lens sp., Lathyrus sp., Cicer sp., Vigna sp*. and *Lupinus sp.*. *Ex situ*

collections are stored under long-term storage conditions with controlled temperature (-18 C° T) and relative humidity (RH - 15%). The largest collections are of: bean (*Phaseolus sp*.) represented by 2000 accessions, followed by: vetch (*Vicia sp.*) - 989 accessions; peanut (*Arachis hypogeae*) - 887 accessions; pea (*Pisum sativum*) - 783 accessions; soybean (*Glycine max*) - 758 accessions and faba bean (*Vicia faba* L.) - 643 accessions. The medium-sized are collections from lentil (*Lens culinaris* Med.) with 402 accessions; grass pea (*Lathyrus* sp. L.) - 333 accessions, cowpea (*Vigna unguiculata* L.) - 302 accessions and chickpea (*Cicer arietinum*) - 269 accessions. The smallest legume collections with less than 100 accessions belong to the lupin (*Lupinus* sp. L.) with 68 accessions and bitter vetch (*Vicia ervilia*) with only 33 accessions. Most of the accessions within these collections were introduced from different geographical regions, but part of them have a native origin (Angelova and Stoilova, 2009).

The aim of the current study is to evaluate the phenotypic diversity of local accessions from five grain legume collections (*Vicia faba*, *Pisum* sp., *Lathyrus* sp., *Cicer arietinum* and *Lupinus* sp.) and to select the best ones with a potential to be used under different agro-climatic conditions.

MATERIALS AND METHODS

The assessment of morphological and agro-biological traits of accessions was performed during 2019-2020 according to the International Descriptor for each crop - *Cicer arietinum* L. of UPOV 2019, for *Lathyrus* spp. IPGRI, 1985, *Lupinus alba* UPOV 2004, *Pisum* sp. UPOV 2000, *Vicia ervilia* and *Vicia faba*, UPOV 2002. During the vegetation period all growing techniques (sowing, weeding, pesticide sprays, ect.) were performed in time, in the optimal period for each crop. The duration of the vegetation period was measured with number of days from start of germination until maturity of 95% plants. The phenological traits were determined with start and end dates of following phases: germination - beginning of flowering, germination – the end of maturity. The yield components were measured on 10 typical plants of each accession, as number of pods per plant, number of grains per plant, number of grains per pod, mass of grains per plant.

The collected data from morphological, agro-biological and agronomical traits were processed using the method of variation (Lidanski, 1988) by determining a sample mean and its error, the minimum and maximum value, standard deviation, variance and coefficient of variation of the each trait. The degree of variability of the traits, represented by the coefficient of variation (CV%), was indicated according to the scheme of Mamaev (Shamov, 1998) as follows: up to 7.0% - very low; 7.1-12.0% - low; 12.1-20.0% - average; 20.1-40.0% - high; over 40.1% - very high.

RESULTS AND DISCUSSION

Pea collection

The main focus of the research work was to create a group of pea accessions with early maturity, high productivity and well adapted to the agro-climatic conditions. The pea genotypes were represented mainly by *Pisum sativum* and several subspecies: ssp. *arvense*, ssp. *sativum*, ssp. *hortense*, ssp. *transcaucasicum*, ssp. *asiaticum*, etc. (pic.1). The indigenous accessions covered a small part of the entire collection. The variation of morphological and agronomical traits is presented in Table 1. Most of the traits showed a high variation: number of grains per pod (25.98%), mass of grains per plant (27.30%), number of grains per plant (33.96%), number of pods per plant (35.04%) and harvest index (35.85%).

The highest average plant height, the

height to the first pod and number of grains per plant were determined in two cultivars: Mir and Vessela. The same cultivars and two local populations (B9E0262 and B9E0263) gave the highest grain yield per plant. The shortest vegetative period (72 days) was observed in spring pea (Amitie cv.). The autumn varieties (Mir and Vessela cvs.) reached maturity phase in 162 days.

Table 1. Variation in morphological and agronomical traits of pea accessions during 2019-2020

Statistical values	Range of variation	Min	Max	Mean / mean error		Standard deviation	Variance	Coefficient of variation, %
Plant height, (cm)	91.10	32.00	123.10	67.96	0.11	33.95	1152.84	49.96
Number of pods/plant	6.41	4.13	10.54	7.02	0.82	2.46	6.05	35.04
Number of grains/plant	20.69	11.60	32.29	23.82	0.03	8.09	65.50	33.96
Mass of grains/plant (g)	2.78	1.86	4.64	3.48	0.32	0.95	0.90	27.30
Number of grains/pod	3.15	2.42	5.57	4.08	0.35	1.06	1.12	25.98
Harvest index (%)	248.47	114.42	362.89	263.52	0.31	94.47	8924.68	35.85
Vegetative period (days)	142.00	75.00	217.00	117.44	0.19	56.57	3199.78	48.17
Germination-beginning of flowering (days)	127.00	36.00	163.00	75.67	0.17	49.71	2471.5	65.69

Chickpea collection

The collection of chickpea (*Cicer arietinum*) is represented by genotypes with a different origin and status (pic. 2). The first evaluation of local and foreign chickpea materials dates back to 1920, related to the beginning of the chickpea breeding activities. Most of the old varieties have been lost and only a few of them were preserved until now. The lack of sufficient chickpea varieties creates a need for utilization of genotypes whose suitability to proper agro-climatic conditions has not been examined.

The structural elements of the yield, such as the number of pods and grain per plant, grains size, grain yield per plant etc. have a significant impact on the productivity of the grain legumes. A low variation was observed in the following agronomic traits: plant height - 5.94%, vegetative period - 7.75% and interphase of germination-beginning of flowering - 11.1%. In three local chickpea accessions (A9E0149, B9E0001 and BGR23151) we obtained higher average values than the standard one in following traits: number of pods per plant, number of grains per plant and mass of grains per plant (Table 2).

The accession A9E0121 had the shortest vegetative period (87 days) while B9E0001 had the longest one (107 days).

Ascochyta blight, caused by *Ascochyta rabiei* (Pass.) Labr., is one of the most important fungal diseases on chickpea (*Cicer arietinum*) in Bulgaria. Resistance to three ascochyta isolates was established in accession BGR 21227 and Balkan cv.; BGR 1915 accession and Progress cv. expressed resistance towards two isolates (VD-7 and B-10) and incomplete resistance to isolate B-10 (Chavdarov and Petrova, 2012). Other common diseases of chickpea were sclerotic rot, caused by the ascomycete fungus *Sclerotinia sclerotiorum*, gray rot - *Botrytis cinerea*, rot of seeds, germines and root system caused by various soil pathogens.

During the recent years serious attacks were observed by Fusarium wilt caused by *Fusarium oxisporum f.sp. ciceri*. The main reason was the favorable climatic conditions with high temperature and a water deficit.

From all studied chickpea accessions under a field condition 50 genotypes showed resistance. Nine accessions with a Bulgarian origin showed a high resistance to Fusarim wilt under artificial inoculation in the pod experiment and a field natural infection (Petrova and Chavdarov, 2012). Some of them possessed a high average value of structural elements of yield.

Table 2. Variation in morphological and agronomical traits of chickpea accessions during 2019-2020

Statistical values	Range	Min	Max	Mean / mean error		St. Dev.	Variance	CV (%)
Plant height (cm)	7.59	41.58	49.17	44.58	0.01	2.65	7.03	5.94
Number of pods/plant	34.09	24.08	58.17	35.50	0.06	15.28	233.62	43.04
Number of grains/plant	35.50	23.75	59.25	37.19	0.06	14.94	223.12	40.17
Mass of grains/plant (g)	13.68	9.55	23.23	14.40	0.02	5.15	26.55	35.76
Number of grains/pod	15.25	37.00	52.25	41.34	0.02	6.02	36.26	14.56
Harvest index (%)	46.68	91.46	138.14	116.89	0.07	16.15	260.88	13.81
Vegetative period (day)	20.00	87.00	107.00	97.50	0.03	7.56	57.10	7.75
Germination-beginning of flowering (day)	16.00	40.00	56.00	50.00	0.02	5.55	30.80	11.1

Vicia faba collection

Nowadays faba bean (*Vicia faba*) is grown in limited area for green pods as a vegetable plant mainly for human consumption (pic. 3). The faba bean varieties which were grown through the recent years were introduced from other countries. There was no breeding of faba bean in our country. Currently in Bulgaria faba bean is grown most of all by private farmers on limited areas for their own consumption. The priority of the current research work was to collect landraces, evaluate and store under controlled conditions at the IRGR gene bank.

The variation of the most important morphological and agronomic traits in faba bean is presented in Table 3. The coefficient of variation (CV%) of the vegetative period (1.78%) and germination-beginning of flowering (1.09%) was low. The number of pods per plant (20.83%), number of pods per plant (22.49%) and harvest index (25.51%) had high coefficient of variation. The vegetative period of the studied faba bean accessions was average 196 days.

Table 3. Variation in morphological and agronomical traits of faba bean accessions during 2019-2020

Statistical values	Range of variation	Min	Max	Mean / mean error		Standard deviation	Variance	Coefficient of variation, %
Plant height (cm)	28.17	54.83	83.00	70.11	0.02	7.95	63.21	11.34
Number of pods/plant	17.33	16.67	34.00	23.70	0.02	5.33	28.39	22.49
Number of grains/plant	33.58	42.17	75.75	55.31	0.03	11.52	132.82	20.83
Mass of grains/plant (g)	6.15	7.68	13.83	10.25	0.56	1.96	3.83	19.12

Number of grains per pod	5.60	18.10	23.70	20.79	0.55	1.89	3.57	9.09
Harvest index (%)	205.72	210.49	416.21	269.34	0.20	68.70	4718.91	25.51
Vegetative period (day)	12.00	190.00	202.00	195.86	0.01	3.48	12.12	1.78
Germination-beginning of flowering (day)	2.00	60.00	62.00	60.55	0.19	0.66	0.43	1.09

From all studied accessions, three local faba bean populations (B1E0434, B1E0218 and B9E0044A) had plant height, height to first pod and number of grains per pod above the average standard.

Other five local forms (B1E0216, B1E0218, B1E0234, B1E0239 and B2E0319) had average values of the number of pods and grains per plant above the standard.

The most common diseases of faba bean were rust (*Uromyces fabae*), bacteriosis (*Pseudomonas margimalis*), alternaria (*Alternaria alternate* Nees) and chocolate spots (*Botritis fabae*).

Collections of alternative grain legumes

The climate changes and the forecasts of the future are a prerequisite for change in the species and the varietal structure of the protein crops in our country, giving priority to drought-resistant and cold-resistant forms with a rapid growth and development and a good adaptation to climatic anomalies.

Lupin (*Lupinus* sp.) (pic. 4) along with the grass pea (*Lathyrus sp.*) (pic. 5) and bitter vetch (*Vicia ervilia*) (pic. 6) can be grown on acidic soils, or with low fertility, or highly eroded. These crops are not very familiar to our producers, but could be included in the structure of protein crops and occupy areas that are not suitable for traditionally grown grain legumes - soybean, pea, bean and chickpea.

Bitter vetch (Vicia ervilia)

The average values of the structural elements of yield were studied in several local accessions of bitter vetch (*Vicia ervilia*). The Rhodope variety has a bigger number of pods and grains per plant, while the local form B9E0168 had a highest plant height and height to the first pod.

Grass pea (*Lathyrus* sp.)

Four of all studied local grass pea accessions (55E12, 559, 57E08 and 556) had the highest plant height compared to standard one. Two of them (57E08 and 556) had a larger number and mass of grains per plant compared to the average standard. The biggest mass of 100 grains was established in 556, 57E08 and 558 (with values of 11.3 g, 13.8 g, 12.5 g, respectively).

Lupin (Lupinus sp.)

During the current evaluation of local white lupin accessions the highest plant height and height to the first pod was observed in BGR 3086 (46.8 cm and 32.2 cm, respectively). The mass of 100 grains of this accession was 26.9 g. In the same accession, also the big number of pods and grains per plant was established.

It is worth to mention also that some of the tested accessions in a previous study showed field resistance to *Fusarium oxysporum* f. sp. *lupini* with damages below 10.0% (BGR 3079 и BGR 3086). Other five accessions demonstrated average resistance with range from 11.0% to 40.0%. These genotypes will be interesting to be included in breeding programs as parental donors for improved grain productivity and resistance to Fusarium wilt (Petrova and Chavdarov, 2020).

Picture. 1. *Pisum sativum*

Picture. 2. *Cicer arietinum*

Picture. 3. *Vicia faba*

Picture. 4. *Lupinus albus*

Picture. 5. *Lathyrus sativus*

Picture. 6. *Vicia ervilia*

Pictures. **1-6.** Local grain legumes accessions (experimental field IRGR, Sadovo) provided by Assist. Prof. Dr. Sofia Petrova

CONCLUSIONS

The change in the agro-climatic environment leads to a new zoning of the agricultural crops; introduction of non-traditional to new species; change in varietal structure; terms and norms of sowing; cultivation technology, etc.

The inclusion of the variety of species, varieties and forms of grain legumes in production is an important future alternative of the agricultural production. Especially in the case of climate change associated with drought, warming, change in the duration of some of the seasons or their displacement over time gives priority to drought-resistant and cold-resistant forms with a rapid growth and development and a good adaptation to major climatic anomalies.

The variability of agronomic and biological traits has shown a high genetic diversity in evaluated grain legume collections and increased the possibilities for their use in the breeding-improvement activity. Based on a phenotyping assessment several grain legume accessions were distinguished as starting breeding materials: from pea collection - two cultivars (Mir and Vessela) and two local populations (B9E0262 and B9E0263); from chick pea collection - four populations (A9E0149, B9E0001, A9E0121 and BGR23151); from faba bean collection – (B1E0434, B1E0218, B1E0216, B1E0218, B1E0234, B1E0239, B2E0319 and B9E0044A); from bitter vetch collection – Rhodope cv. and B9E0168; from grass pea collection - (55E12, 559, 57E08, 556, 57E08 and 558); from white lupin collection - BGR 3079 and BGR 3080.

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