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AGRO-MORPHOLOGICAL ASSESSMENT OF THREE ALTERNATIVE GRAIN LEGUME CROPS

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Abstract

The grain legume crops are an important component of agricultural biodiversity and food security, because of the rich protein food and fodder, and a source of income. The aim of the current study was to evaluate the agro-morphological diversity of three alternative grain legume crops (*Cicer arietinum* L., *Lathyrus* sp. L. and *Vicia ervilia* L.) and to select the best accessions with a high yield potential. The assessment of the agro-morphological traits was performed according to the International Descriptors' of each crop. High variation for *Lathyrus* sp. L. accessions was observed in the following agronomic traits: plant height, height to the first pod, number of pods per plant, number of grains per plant, mass of grains per plant and mass of 100 grains; for *Cicer arietinum* L. - number of grains per plant and mass of grains per plant and for *Vicia ervilia* L. - height to the first pod, number of pods per plant, number of grains per plant and mass of grains per plant. The variability of quantitative traits has shown a high genetic diversity in the evaluated accessions from alternative grain legume collections. The group of early grasspea accessions embraced twelve accessions. Three local chickpea populations had the shortest vegetative period from 86.7 days. Two bitter vetch accessions from the early group possessed positive yield traits. Based on the results obtained from this study, the best accessions were selected, for example: from *Cicer arietinum* L. - seven accessions; from *Lathyrus sp.* L. – five accessions and from *Vicia ervilia* L. – five accessions. According to these results, it can be concluded that the best accessions will be used for the next experimental trials and will be recommended to all interested researchers, breeders and farmers.

Keywords: grasspea (*Lathyrus* sp. L.), chickpea (*Cicer arietinum* L.), bitter vetch (*Vicia ervilia* L.), agro-morphological assessment

INTRODUCTION

The grain legume crops are ancient crops of modern times and their cultivation dates back to the pre-historic time. Due to their high nutritional value and the opportunity of cultivation in poor environments, mainly dry ecologies, they are an integral part of the daily dietary system of millions of people around the world. The protection of the land races is a necessary preventive measure since villages are endangered by depopulation and aging of the rural population (Angelova et al., 2013).

Lathyrus species grown commercially include *Lathyrus sativus L.*, *Lathyrus cicera* L. and *Lathyrus odoratus* L. which are also the most economically important. Breeding programs aim to improve its yield, quality and adaptability. All these breeding efforts require access to suitable genetic resources (Vaz Patto & Rubiales, 2014). Diversity is an important resource and a guarantee for improving the species of interest. It is also the source of new genes for combating threats to agricultural production caused by biotic or abiotic factors (Frankel et al., 1995; Gepts, 2006). The evaluation of genetic diversity among accessions could be an invaluable aid in the crop improvement strategies.

According to statistics, 92% of the chickpea areas and 75.4% of the seed production are concentrated in areas with a lack

of moisture (FAOSTAT, 2007). Chickpea seeds provide essential minerals (Na, I, Se and Cr) important for human health (Zatochova et al., 2022). One of the main aims of the chickpea breeding program is improving the productive potential (Mehandzhiev et al., 2002). Yield is a major consideration for any breeding program (Afreen et. al., 2017). It is the resultant product for various morphological, physiological and biological components (Bandi et al., 2018). To achieve an increase in the biological potential of the yield, the criteria for selection of the source material must be focused on: morphological traits – plant height and the number of main branches per plant; a phenological trait – short vegetation period; resistance to abiotic and biotic stress – drought, cold, fungal and viral diseases.

According to Sadeghi et al. (2009), given the increasing costs of conventional foods such as corn, soy bean, flour, etc., it is necessary to find cheaper alternatives. In this connection, the bitter vetch has many favorable traits, such as high yields, resistance to drought and insects. According to the same authors, the bitter vetch is a good source of energy for metabolism (13, 57 MJ/kg), protein (240 g/kg) and minerals, especially Fe, Cu, K, P and Cl. The culture contains a small amount of fat, but it is high in non-structural carbohydrates (617, 8 g/kg). Its amino acid profile is very close to soybean flour, including being a good source of lysine.

The aim of the current study was to evaluate the agro-morphological diversity of the three alternative legume crops (*Lathyrus* sp. L., *Cicer arietinum* L. and *Vicia ervilia* L.) and to select the best accessions with high yield potential to be used in different direction.

MATERIALS AND METHODS

The experiments were carried out on the experimental field in IPGR - Sadovo on cinnamon forest soil after a precursor of wheat during the period 2019-2020. The field experiments for each crop were designed in Randomized Complete Block Design (RCBD) with four replications. The experiment plots size for each crop was 10.0 m^2. The sowings were made by hand, in optimum sowing time, according to the technology of cultivation for each crop. The assessment of the morphological and agro-biological traits of accessions was performed according to the International Descriptor for each crop - *Cicer arietinum* L. of UPOV 2000, for *Lathyrus* spp. IPGRI, 2000 and *Vicia ervilia* L. All studded accessions from each crop are landraces. During the vegetation period all growing techniques (sowing, weeding, pesticide sprays, etc.) were performed in time, in the optimal period for each crop. The duration of the vegetation period was measured with the number of days from the start of germination until maturity of 80% of the plants. The yield components were measured on 10 typical plants of each accession, as number of pods per plant, the number of grains per plant, the number of grains per pod, mass of grains per plant and mass of 100 grains.

The collected data from the agro-biological traits were processed using the method of variation (Lidanski, 1988) by determining the sample mean and its error, minimum and maximum value, standard deviation, variance and the coefficient of variation for 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. The obtained results were processed using the statistical package SPSS 19.0. for Windows.

RESULTS AND DISCUSSION

Grasspea (*Lathyrus* sp. L.)

The structural elements of the yield, such as the number of pods and grain per plant, grain size, grain yield per plant etc. have a significant impact on the productivity of the

grain legumes. The characterized morphological descriptors displayed a broad range of phenotypic variation among the evaluated accessions (Table 1). A high variation between the accessions was observed for the following agronomic traits: plant height, height to the first pod, number of pods per plant, number of grains per plant, mass of grains per plant and mass of 100 grains. On the other hand, a low variation was established for a number of main branches (11.50%) and a very high – for the days to maturity (56.90%). The earliness of the accessions was established by the number of days until reaching the maturity cycle. They varied from 72.40 to 129.00 days. The genotype BGR33111 had the shortest vegetative period, while an accession 6469 had the longest one. The group of early accessions embraced twelve accessions (less than 100 days). Three genotypes (55E12, 558 and 57E7) from this group combined the earliness with the biggest number of grains and pods per plant. The very early genotypes (BGR33111 and BGR40415) reached the average values for some of the traits such as the number of grains per plant, number of main branches, number of grain per pod and mass of grains per plant. Dixit et al. (2016) considered that the agronomically important traits of the grass pea accessions should be varied as follows: earliness (< 100 days), number of pods (> 50 per plant), grain yield (> 10 g/plant) and seed size (> 12 g/100 seed). In our experiment the accessions 55E12, 558 and 57E7 came close to these requirements.

Table 1. Phenotypic variation of the agro-morphological traits of *Lathyrus sp.* accessions.

Accessions	Plant height (cm)	Height to the first pod (cm)	Number of main branches	Number of pods per plant	Number of grains per plant	Number of grains per pod	Mass of grains per plant (g)	Mass of 100 grains (g)	Days to maturity
59101	41.8	21.6	3.5	9.8	56.6	8.9	0.7	1.0	106.0
5717	56.4	20.1	3.7	13.4	26.6	2.8	5.2	19.6	111.0
6469	59.1	16.9	3.0	29.4	71.1	3.2	13.9	19.4	129.0
80208	72.6	21.4	3.4	27.5	58.6	2.5	11.2	20.2	111.0
B6E03965	63.7	20.5	3.2	23.3	44.5	2.6	9.5	22.2	108.0
80231	64.4	17.9	3.7	36.7	78.7	3.2	13.5	18.8	113.0
80222	69.8	17.3	3.4	28.1	57.9	2.8	14.1	25.2	129.0
80208	63.4	17.2	3.3	21.6	46.4	3.2	11.4	24.8	111.0
80223	63.3	17.1	3.1	23.9	44.7	2.5	11.1	23.9	111.0
80225	71.6	21.4	3.7	30.0	66.4	2.7	13.9	20.9	113.0
6494	74.9	23.1	2.9	14.5	44.9	4.0	4.4	11.3	98.0
56156	193.1	38.5	3.3	10.5	2.4	2.8	0.1	9.2	108.0
BGR40415	**75.4**	**22.2**	**2.8**	**26.5**	**63.9**	**3.0**	**10.3**	**16.9**	**75.4**
556	83.6	22.1	2.8	29.4	73.3	3.1	13.0	19.5	83.6
57E7	**80.3**	**23.8**	**3.3**	**34.1**	**83.2**	**2.7**	**15.5**	**21.5**	**80.3**
558	**80.2**	**25.4**	**3.5**	**33.2**	**73.8**	**3.0**	**13.5**	**19.1**	**80.2**
559	89.4	22.5	2.9	27.1	60.8	2.7	12.3	22.0	89.4
5510	79.3	25.9	2.5	29.8	69.8	2.8	12.2	20.0	79.3
5511	74.1	23.6	2.7	26.3	64.8	3.0	10.0	20.7	74.1
55E12	**91.3**	**25.7**	**2.9**	**33.4**	**80.4**	**2.9**	**14.1**	**20.2**	**91.3**
5726	82.1	31.2	2.6	29.3	66.8	3.2	13.7	21.4	82.1
BGR 33111	**72.4**	**19.8**	**3.0**	**25.6**	**72.2**	**3.0**	**10.5**	**16.9**	**72.4**
97BM0001	80.6	30.3	2.8	24.3	50.1	2.6	8.8	20.0	80.6
Mean/ Error of mean	**77.5 ±0.07**	**22.8 ±0.05**	**3.1 ±0.08**	**25.6 ±0.06**	**59.0 ±0.07**	**3.2 ±0.27**	**10.6 ±0.88**	**18.9 ±0.06**	**111.5 ±0.01**
Min	**41.8**	**16.9**	**2.5**	**9.8**	**2.4**	**2.5**	**0.1**	**1.0**	**98.0**
Max	**193.1**	**38.5**	**3.7**	**36.7**	**83.2**	**8.9**	**15.5**	**25.2**	**129.0**
CV (%)	**35.60**	**22.46**	**11.50**	**28.68**	**31.44**	**40.57**	**39.87**	**28.27**	**56.90**

*Max – maximum value; Min – minimum value; CV –coefficient of variation (%).

Chickpea *(Cicer arietinum* L.*)*

The phenotypic variation of the agro-morphological traits of *Cicer arietinum* L. is presented in Table 2. Some of the traits showed a very high variation: number of grains per plant (42.50 %) and mass of grains per plant (43.56%). A low variation was observed in the following agronomic traits: days to maturity (8.15%) and number of grains per pod (9.87%). Similar to our study Aktar-Uz-Zaman et al. (2020) established that the quantitative characteristics such as the number of grains per plant and the grain yield per plant showed the maximum variability among the other studied traits.

One of the most important characteristics for the grain legumes is their earliness in reaching flowering and maturity cycle for a short period in order to avoid high temperatures and low air humidity during the flowering and podding stages (Stoilova & Berova, 2009).

The evaluated chickpea accessions were characterized by an early and medium maturation, with the number of days to reaching the maturity cycle varied from 86.67 to 96.67 days. Three local chickpea populations (85E0264, 85E0265 and 85E0266) had the shortest vegetative period (86.7 days). They combined their earliness with a high number of pods per plant. The local genotype from Goliamo Krushevo village (85E0259) is characterized with the longest period for maturation (96.7 days).

Four local chickpea accessions (5418, 71230, 85E0263 and 85E0262) differed from the others by the high number of pods per plant, number of grains per plant and number of grains per pods. One of them (85E0262) also had a short vegetative period (87.33 days). Three accessions (B0BM0037, B0BM0038 and 85E0260) showed the highest value of mass of 100 grains as 43.95 g, 40.35 g and 42.68 g, respectively.

As initial breeding materials, the following accessions are recommended: 85E0264, 85E0265, 85E0266, 5418, 71230, 85E0259 and 85E0262.

Bitter vetch (*Vicia ervilia* L.)

The variation of the agronomical traits is presented in Table 3. Some of the traits showed a high variation: height to the first pod (24.07%), number of pods per plant (23.36%), number of grains per plant (25.37%) and mass of grains per plant (31.82%). A very low variation was observed in the following agronomic traits: number of main branches (6.75%) and days to maturity (6.84%).

Provisionally we separated the studied accessions according to their days to maturity into two groups (early from - 78 to 91 days and mid early - from 92 to 101 days). Two accessions (BGR6180 and BGR3020) from the early group possessed other positive yield traits such as big number of grains and pods per plant, big number of grains per pod, high mass of grains per plant, high 100 grains mass and high harvest index. Three local forms (BGR3051, BGR3052 and B9E0168) from the group of the mid early characterized by tall plants, big number of main branches and the high first pod formation. As initial breeding materials, the following accessions are recommended: BGR3020, BGR6180, BGR3051, BGR3052 and B9E0168.

CONCLUSION

A high genetic variability in the agronomic and morphological traits was established in the IPGR collections of the three alternative legume crops (*Cicer arietinum* L., *Lathyrus* sp. L., and *Vicia ervilia* L.). In *Lathyrus* sp. L. accessions it concerned the plant height, height to the first pod, number of pods per plant, number of grains per plant, mass of grains per plant and mass of 100 grains; in *Cicer arietinum* L. - the number of grains per plant and mass of grains per plant and for *Vicia ervilia* L. – the height to the first pod, number of pods per plant, number of grains per plant and mass of

grains per plant.

Based on the agro-morphological assessment, several grain legume accessions were distinguished as the best from all studied genotypes: from the grasspea collection – five populations (55E12, 558, BGR 33111, BGR40415 and 57E7); from the chickpea collection - seven genotypes (85E0264, 85E0265, 85E0266, 5418, 71230, 85E0259 and 85E0262); the bitter vetch collection - BGR3020, BGR6180, BGR3051, BGR3052 and B9E0168. The variability of the quantitative traits has shown a high genetic diversity in the evaluated alternative grain legume collections. The best accessions will be used for the next experimental trials and will be recommended to all interested researchers, breeders and farmers.

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Table 2. The phenotypic variation of the agro-morphological traits of *Cicer arietinum* L. accessions.

Accessions	Plant height (cm)	Height to the first pod (cm)	Number of main branches	Number of pods per plant	Number of grains per plant	Number of grains per pod	Mass of grains per plant (g)	Mass of 100 grains (g)	Days to maturity
A8BM0071-St	46.83	34.57	6.70	32.67	35.40	1.16	13.78	39.18	92.3
A8BM0072	52.27	37.20	5.43	23.27	26.33	1.11	10.77	39.30	91.0
B0BM0037	47.70	34.53	5.27	24.17	25.73	1.18	8.54	43.95	90.7
B0BM0038	51.23	35.80	5.30	24.00	25.83	1.27	10.81	40.35	93.00
548	49.17	36.57	6.30	34.30	43.73	1.67	11.99	27.10	91.67
5410	44.37	32.73	6.57	29.37	34.83	1.32	9.45	28.33	90.67
5412	48.77	35.43	6.37	33.70	43.17	1.64	11.43	28.07	91.00
5415	48.27	34.63	6.20	30.43	35.73	1.41	10.24	28.43	90.67
5418	**51.03**	**38.57**	**7.47**	**42.60**	**54.23**	**1.64**	**11.18**	**25.78**	**90.33**
71228	42.60	30.60	6.93	33.00	44.53	1.61	12.78	29.52	89.67
71230	**44.07**	**28.80**	**6.93**	**43.03**	**60.33**	**1.73**	**12.72**	**20.60**	**88.33**
6388	48.93	32.97	6.13	32.27	37.67	1.41	10.92	28.78	89.00
71229	40.93	29.53	6.30	39.13	39.87	1.16	12.97	31.42	91.00
17	47.40	32.33	5.67	32.00	40.23	1.45	10.84	27.65	93.00
50	47.93	34.40	6.40	36.77	44.40	1.31	9.75	27.85	88.67
193	47.30	32.63	6.00	36.77	52.83	1.81	11.47	21.08	89.67
85E0162	39.10	25.10	5.80	38.55	40.50	1.10	13.27	32.10	89.50
85E0259	51.17	32.20	4.60	25.67	27.67	1.13	8.46	33.87	96.67
85E0160	40.30	31.77	5.00	32.43	36.33	1.71	9.78	23.30	92.00
85E0260	43.30	26.33	5.27	24.43	23.83	1.00	10.46	42.68	94.67
85E0261	40.80	26.57	6.43	40.17	44.13	1.26	11.18	29.18	90.67
85E0262	**39.27**	**24.87**	**6.50**	**43.67**	**46.63**	**1.12**	**14.95**	**35.98**	**87.33**
85E0263	**40.63**	**25.27**	**6.27**	**40.13**	**41.70**	**1.07**	**13.60**	**32.13**	**89.33**
85E0264	**41.83**	**25.63**	**6.20**	**36.30**	**42.50**	**1.44**	**11.06**	**28.48**	**86.67**
85E0265	**41.97**	**29.07**	**6.90**	**35.40**	**38.80**	**1.29**	**14.28**	**36.45**	**86.67**
85E0266	**39.23**	**24.27**	**5.67**	**33.83**	**34.00**	**1.05**	**12.25**	**37.87**	**86.67**
85E0267	40.97	26.43	5.57	27.93	30.83	1.22	14.26	45.02	89.67
Mean/ Error of mean	**44.91 ±0.04**	**30.78 ±0.05**	**6.55 ±0.25**	**33.20 ±0.97**	**38.38 ±0.12**	**1.33 ±0.12**	**11.56 ±0.12**	**32.40 ±0.03**	**90.36 ±0.02**
Min	**43.30**	**21.90**	**1.40**	**4.60**	**17.50**	**3.84**	**5.60**	**27.90**	**87.33**
Max	**68.43**	**38.00**	**4.43**	**15.14**	**64.43**	**5.03**	**22.20**	**40.80**	**96.67**
CV (%)	**15.44**	**18.45**	**31.72**	**36.78**	**42.22**	**9.87**	**43.56**	**11.38**	**8.15**

*Max – maximum value; Min – minimum value; CV –coefficient of variation (%).

Table 3. The phenotypic variation of the agro-morphological traits of *Vicia ervilia* L. accessions.

Accessions	Plant height (cm)	Height to the first pod (cm)	Number of main branches	Number of pods per plant	Number of grains per pod	Number of grains per plant	Mass of grains per plant (g)	Mass of 100 grains (g)	Days to maturity
BGR3052	**50.17**	**28.00**	**3.67**	**25.67**	**2.73**	**49.83**	**1.17**	**2.40**	**101.00**
BGR3051	**59.67**	**32.17**	**3.83**	**26.67**	**2.40**	**48.33**	**1.18**	**2.50**	**100.00**
B9E0168	**55.00**	**27.50**	**3.67**	**39.50**	**2.57**	**74.33**	**2.47**	**3.40**	**98.00**
BGR6207	42.33	25.00	3.67	32.67	3.17	74.83	2.33	3.30	92.00
A3BM0178	51.50	23.50	3.67	43.67	2.57	77.33	1.92	2.70	90.00
BGR13526	46.50	24.67	3.33	40.33	2.80	61.83	2.30	3.80	94.00
BGR6180	**35.50**	**14.17**	**3.33**	**46.83**	**2.77**	**79.17**	**2.50**	**3.50**	**90.00**
BGR3019	39.33	16.17	3.67	47.83	2.33	61.17	1.97	3.20	92.00
BGR3020	**37.83**	**21.83**	**3.17**	**50.00**	**3.17**	**92.33**	**3.32**	**3.85**	**78.00**
BGR3024	38.50	16.83	3.17	29.83	2.63	37.00	1.35	3.50	89.00
BGR3048	41.50	21.50	3.33	31.50	2.53	55.33	1.90	3.70	91.00
Mean/ Error of mean	**45.26 ±0.05**	**22.85 ±1.66**	**3.50 ±0.07**	**37.68 ±0.07**	**2,70 ±0.08**	**64.68 ±0.08**	**2.04 ±0.20**	**3.26 ±0.08**	**92.27 ±0.08**
Min	**35.50**	**14.17**	**3.17**	**25.67**	**2.33**	**37.00**	**1.17**	**2.40**	**78.00**
Max	**59.67**	**32.17**	**3.83**	**50.00**	**3.17**	**92.33**	**3.32**	**3.85**	**101.00**
CV (%)	**17.41**	**24.07**	**6.75**	**23.36**	**10.17**	**25.37**	**31.82**	**15.66**	**6.84**

*Max – maximum value; Min – minimum value; CV –coefficient of variation (%).

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