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Breeding Evaluation of Chickpea (*Cicer arietinum* L.) Varieties in the Pannonian Conditions

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ABSTRACT

Chickpea (*Cicer arietinum* L.) is a widely cultivated pulse crop whose seeds are rich in proteins and carbohydrates, accounting for approximately 80% of their dry weight. Due to their nutritional value and associated health benefits, chickpea seeds are often classified as a "functional food". In the present study, 22 chickpea varieties belonging to the "desi", "kabuli", and "pea grain" types were evaluated in terms of quantitative and qualitative and qualitative traits. The highest seed weight per plant was recorded in Krajova z Kralovej (34.13 g), Beta (33.44 g), Garbanzo 4 (29.76 g), and Caqui (28.74 g). High crude protein content was demonstrated by FLIP 84-149 (21.27%), Grabonzo 1 (21.18%), and Alfa (20.79%). They can be used in future breeding programs as high-protein sources. A leading factor that determined the variation in expression of the traits biomass weight/plant, number of basal branches, number and weight of seeds per plant, and crude protein content was the environment. Genotype is a major factor in variation in plant height and 1000-seed mass. High variability (CV >20%) was observed for traits such as first pod height, number of pods per plant, number of seeds per plant, and mass of 1000 seeds. Seed weight/plant, pod length, and biomass weight/plant showed medium variability (CV = 10-20%). Low stability (CV <10%) was found for plant height and number of basal branches.

Keywords: chickpea, traits, economical productivity, variability, early ripening.

INTRODUCTION

Global climate change and increasing drought conditions define chickpea as one of the main legume crops suitable for cultivation in regions with insufficient and unstable moisture. Its high drought tolerance, resistance to diseases and pests, and good suitability for mechanized harvesting make chickpea an attractive crop also for better watered regions (Fedotov et al., 2004; Novikov, 2021).

Chickpea is a highly valuable legume crop. It is widely utilized for food purposes, serving as a raw material in the canning and food processing industries, as well as in animal feed production. In terms of nutritional value, chickpea is comparable to pea, lentil, and common bean. Its fat content exceeds that of most other legumes, with the exception of soybean (Kalashnikova and Tertychnaya, 2005; Sadigova et al., 2010).

Depending on the variety, cultivation technology, and climatic conditions, chickpea seeds contain protein (13-31%), fat (4-7%), nitrogen-free substances (45-60%), and ash (2.5-5.0%). In terms of the content of essential amino acids, important for human and animal nutrition, chickpeas are not inferior to peas, common beans, and lentils. The average content of macro- and micronutrients is as follows: K - 968-975, Ca - 190-192, Mg - 126-130, B - 198-200, P - 445 and Fe - 957-960 mg% (Bar-El Dadon et al., 2017; Maphosa et al., 2020). Chickpea seeds contain the following

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vitamins per 100 g: A - 0.17–0.21; B1 - 0.26-0.29; B3 - 0.48-0.55; C - 3.56-3.90; and PP - 2.21–2.36 mg, as well as pyridoxine, pantothenic acid, and choline. In terms of selenium content, chickpeas take first place among legumes (Kaur and Prasad, 2021; Toker et al., 2021).

In recent years, interest in chickpea has grown due to diversification and profitability in its cultivation. Application of fertilization has singificant influence of seed yield increasing (Rajičić et al., 2019; Božović et al., 2020; Ugrenović et al., 2021; Ilin et al., 2025). As a result of long-term research on chickpea varieties for morphological, agronomic, and biological characteristics, including resistance to major diseases, valuable breeding sources have been identified (Baytarakova and Kudaibergenov, 2021; Suleimanova et al., 2021). Global chickpea resources, concentrated in the collections of the world's largest plant gene banks, are the basis for creating new varieties. These include ICRISAT, India (17,258 accessions); ICARDA, Syria (12,448 accessions); SPII, Iran (4,925); USDA-WRPIS, USA (4,662); CLIMA, Australia (4,351); NBPGR, India (3,830); etc. (Taskinbayeva et al., 2022). The variability observed in the studied traits can be largely attributed to environmental influences, which are known to significantly affect chickpea yield and its components (Uyeturk et al., 2023). The investigation and utilization of genetic resources to develop highly productive and tolerant varieties, adapted to the specific conditions of a particular region, is important for sustainable chickpea production and food security (Thudi et al., 2016; Farahani et al., 2019).

The present study aimed to evaluate chickpea varieties in terms of quantitative and qualitative traits and parameters in the conditions of Central Northern Bulgaria.

MATERIAL AND METHODS

Experimental design

The field experiment was conducted with 22 chickpea varieties from a starting collection. Twenty of the varieties were of the “desi” and “pea grain” types (Alfa, Beta, Businsky, Irenka, Krajova z Kralovej, Maskovsky Bagovec, Slovak, FLIP 84-149 C, VSP 11, Balkan, Progress, Caqui, Garbanzo negro, Tadzikskij 10, Sovhoznyj 14, Dneprovskij 1, Garbanzo 2, Garbanzo 3, Garbanzo 4, and Plovdiv 8), and two (Garbanzo 1 and Blanco Lechoso) belonged to the “kabuli” type. All varieties were introduced, except for the Bulgarian varieties Balkan, Progress, and Plovdiv 8. The seeds were sown in rows, with inter-row and intra-row spacing of 50 cm and 15 cm, respectively. The longevity of the main phenological phases (emergence to the beginning of flowering, and the beginning of flowering to full maturity) and the vegetation period were recorded. The coefficient of early-maturing was calculated (Kuzmova, 2002). At the full maturity phase, a biometric analysis was performed regarding the following characteristics: biomass weight/plant (g), number of branches, plant height (cm), height of the 1st pod (cm), number of pods, number of seeds/plant, seed weight/plant (g), mass of 1000 seeds (g), and pod length (cm). The main chemical composition of the seeds was determined as follows: crude protein (by the Kjeldahl method), crude fiber (by the Weende system), phosphorus (colorimetrically, by the hydroquinone method), and calcium (complexometrically, described by Sandev, 1979).

Statistical analisys

The data were processed using analysis of variance (ANOVA) and Duncan's multiple range test. The coefficient of variation (CV%) was calculated using the method of Dimova and Marinkov (1999). Experimental data were analyzed using Excel software and the statistical program SPSS 13.0.

RESULTS AND DISCUSSION

Analysis of variance of quantitative traits

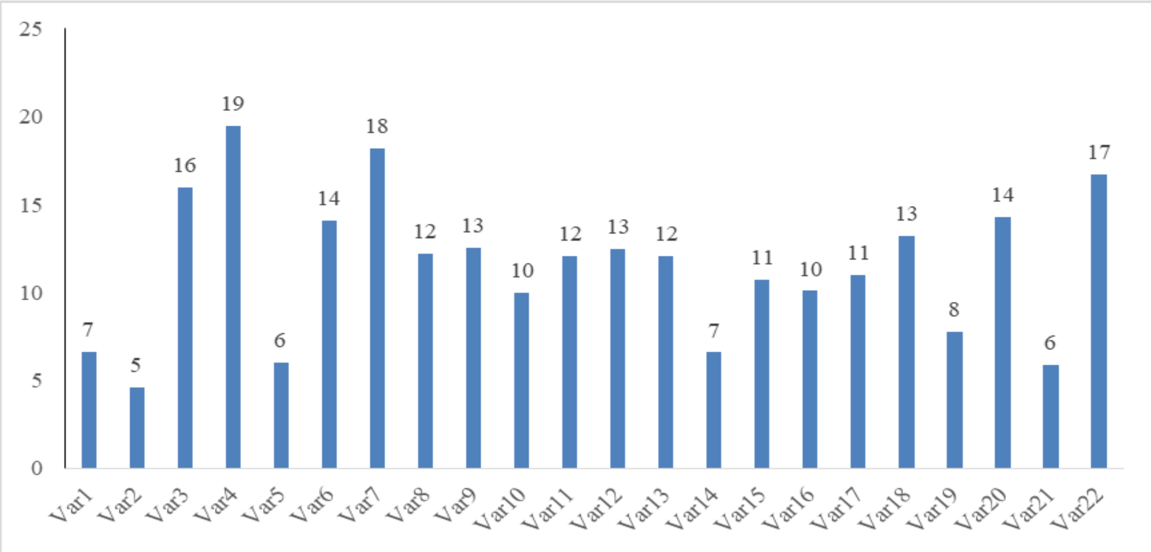
Two-way analysis of variance for genotypes and replicates showed statistically insignificant differences for height/plant, height of 1st pod and pod length (Table 1). For most indicators, the influence of the environmental factor was decisive for the trait's manifestation. The influence of the variety factor has a slight preponderance over the year factor in terms of height/plant and height of 1st pod. Similar results have been obtained by other researchers (Dehal et al., 2016; Katkani et al., 2022; Sharma et al., 2023; Mihoariya et al., 2023) when evaluating chickpea accessions through variance analysis on various indicators (quantitative and qualitative). According to the authors, this considerable variability presents a promising opportunity for improving traits and parameters in chickpea breeding programs. The results of the analysis of variance revealed significant differences between the 22 cultivars tested and in relation to the climatic conditions in the various experimental years. The leading factor determining the expression of the traits biomass weight/plant, number of basal branches, number of seeds/plant, seed weight/plant, number of pods/plant, and pod length was the experimental year. The cultivar is a major factor for variation of plant height, 1st pod height, and 1000-seed mass. The strongest dispersion was for the number of seeds and pods/plant, which is indicative of the influence of environmental conditions on seed productivity formation. The established significant differences between chickpea varieties for the main quantitative traits (number of pods and seeds per plant, seed weight/plant, mass per 1000 seeds) are a good prerequisite for a multilateral evaluation and for the use of some of them as suitable parental components in combinative breeding.

Figure 1 presents a summary of the arithmetic rank score of each variant, based on the ranking method used. Varieties Beta, Krajova z Kralovej, Caqui, and Garbanzo 4 are ranked in higher positions (score 5-7) because they had better productive capabilities. A considerable part of the accessions takes a rank value between 10 (Progress and Tadzikskij 10) and 14 (Maskovsky Bagovec and Garbanzo 3); therefore, they occupied an intermediate position in the overall ranking. The last positions in the arithmetic score (17-18) are occupy by Plovdiv 8 and Slovak, which were poorly productive and did not represent breeding interest. Figure 2 presents the results of the variation analysis of the accessions in terms of the stability of the main quantitative traits. The highest variability was obtained for 1000-seed mass (37.24%) and number of seeds/plant (31.93%). The highest variability was obtained for 1000-seed mass (37.24%) and number of seeds/plant (31.93%). High coefficients of variation were also found for the number of pods (26.28%) and height of 1st pod (23.07%), but the values were relatively lower than those for the first two traits. Seed weight/plant (18.94%), pod length (13.78%), and biomass weight/plant (12.98%) were characterized by an average level of variability. The highest stability (7.72 and 9.63%) was recorded in terms of height/plant and number of basal branches (7.72 and 9.63%). The genetic differences in the chickpea accessions from the studied collection, and the environmental conditions, are a prerequisite for the existence of strong variability in some of the traits.

Table 1. Dispersion analysis of the chickpea varieties according to the studied characters

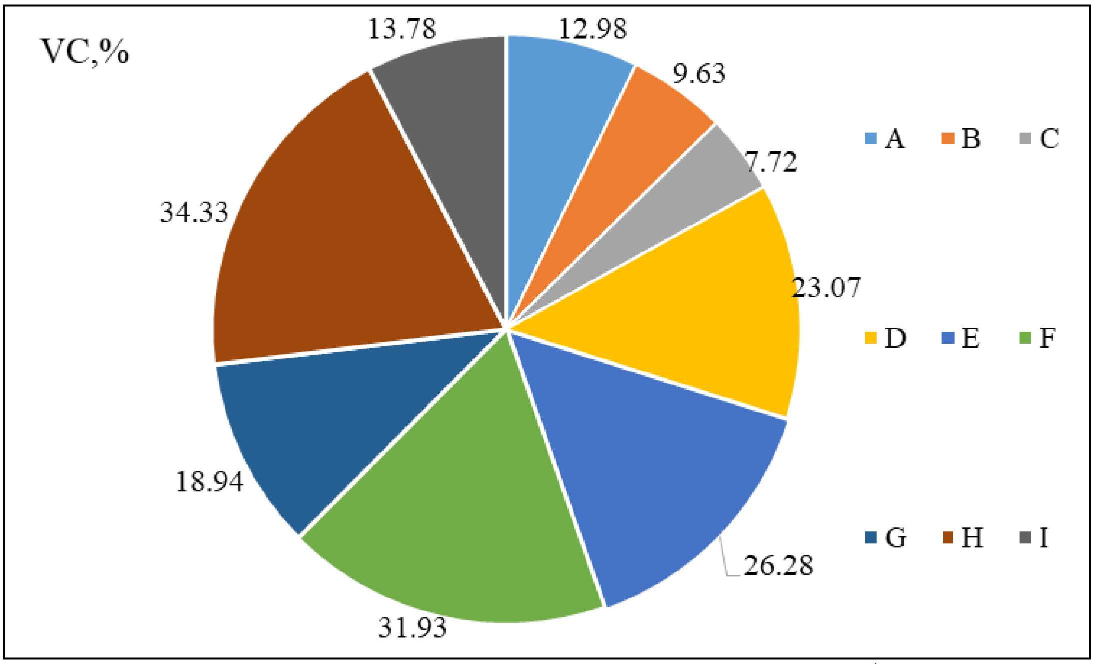
Source of variation	df	MS				
		Biomass weight/plant	Number of branches	Height/plant	Height of 1st pod	Number of pods/plant
Year	2	2,037.5**	3.40**	11.0865	2,202.26	5,256.4**
Variety	21	205.7227	0.306	66.8327	3,212.85	1,432.2**
Error	42	187.5797	0.3103	41.823	3,228.83	486.6798
Corr. total	65					
Source of variation	df	Number of seeds/plant	Seed weight/plant	1000 seeds mass	Pod length	
Year	2	9,688.6**	582.75**	2,908.68*	637.03	
Variety	21	2,596.57*	65.66*	3,819.01**	633.67	
Error	42	1,251.296	32.1136	4,166.26	635.51	
Corr. total	65					

significance at *P < 0.05, ** P < 0.01.



Var1-Alfa, Var2-Beta, Var3-Businsky, Var4-Irenka, Var5-Krajova z Kralovej, Var6-Maskovsky Bagovec, Var7-Slovak, Var8-FLIP 84-149 C, Var9-VSP 11, Var10-Progress, Var11-Balkan, Var12- Garbanzo 1, Var13-Blanco Lechoso, Var14-Caqui, Var15-Garbanzo Negro, Var16-Tadzikskij 10, Var17-Sovhoznyj 14, Var18-Dneprovskij 1, Var19-Garbanzo 2, Var20-Garbanzo 3, Var21- Garbanzo 4, Var22-Plovdiv 8.

Figure 1. Results of the variation analysis of the accessions in terms of the stability of the main quantitative traits



A-biomass weight/plant, B-number of branches, C-height/plant, D-Height of 1st pod, E-number of pods/plant, F-number of seeds/plant, G-seed weight/plant, H-1000-seed mass, I-Pod length.

Figure 2. Coefficient of variation for quantitative traits in chickpea varieties

Longevity of growing season

The growing season longevity determines the cultivar's adaptability to the respective climatic zone conditions. The importance of studying the growing season is also determined by the fact that many economic and biological traits, such as grain quality, pest tolerance, and productivity, are related to this trait. When testing new accessions, it is necessary to find forms that combine early maturity with high productivity.

The onset of a particular phenological phase depends on the genetic basis of the studied object and the environmental conditions, which influence the duration of each phase and the entire growing season. The average duration of the period of germination - beginning of flowering was 51 days (Table 2). Several groups were distinguished. The accessions with a longer duration (53-60 days) of the period were Plovdiv 8, Irenka, Slovak, Sovhoznyj 14, Dneprovskij 1, Progress, and Balkan. The group of earlier flowering genotypes included Alfa, Beta, Businsky, Krajova z Kralovej, Grabonzo 1, Blanco, Lechoso, FLIP 84-149 C, and VSP 11.

The interphase period from the beginning of flowering to full maturity ranged from 40 to 62 days, with an average of 51 days. In this regard, Plovdiv 8 (40 days), Irenka (45 days), Sovhoznyj (46 days), Dneprovskij 1 (47 days), Slovak (47 days), and Maskovsky Bagovec (49 days) were distinguished. Their duration was below the average value for the studied collection. The longest duration of this period was observed in Blanco Lechoso (62) and Garbanzo 1 (59), which are of the "kabuli" type. On average, for all studied accessions, the duration of the growing season was 102 days. VSP 11 was the only variety with a vegetation period of under 90 days (89 days). For more than half of the varieties (Beta, Businsky, Irenka, Krajova z Kralovej, Maskovsky Bagovec, FLIP 84-149 C, Caqui, Garban negro, Tadzikskij 10, Sovhoznyj 14, Dneprovskij 1, Garbanzo 2, Garbanzo 4, and Plovdiv 8), the growing season ended in 100-103 days. The vegetation period with the longest duration (104-106 days) was for Alfa, Progress, Balkan, Grabonzo 1, Blanco Lechoso, and Garbanzo 3.

According to the coefficient of early maturing, VSP 11 can be defined as an ultra-early-maturing variety (1.00). The medium early-maturing group (from 1.4 to 1.66) included Maskovsky Bagovec, FLIP 84-149 C, Garban negro, Tadzikskij 10, Dneprovskij 1, and Plovdiv 8. The group of late-ripening varieties was formed by Alfa, Beta, Businsky, Irenka, Krajova z Kralovej, Slovak, Progress, Balkan, Grabonzo 1, Blanco Lechoso, Caqui, Sovhoznyj 14, Garbanzo 2, Garbanzo 3, and Garbanzo 4.

Table 2. Longevity of phenological phases in chickpea varieties

Variety	Germination - beginning of flowering (days)	Beginning of flowering - full maturity (days)	Vegetation period (days)	Coefficient of early maturing
Alfa	49	56	105	1.94
Beta	49	53	102	1.75
Businsky	49	54	103	1.80
Irenka	57	45	101	1.71
Krajova z Kralovej	48	55	103	1.82
Maskovsky Bagovec	50	49	100	1.61
Slovak	57	47	104	1.86
FLIP 84-149 C	47	53	100	1.65
VSP 11	38	51	89	1.00
Progres	54	50	104	1.86
Balkan	55	51	106	2.00
Grabonzo 1	46	59	104	1.88
Blanco Lechoso	43	62	104	1.88
Caqui	52	49	101	1.69
Garban negro	52	49	100	1.65
Tadzikskij 10	49	51	100	1.63
Sovhoznyj 14	57	46	103	1.82
Dneprovskij 1	53	47	100	1.65
Garbanzo 2	50	52	102	1.76
Garbanzo 3	52	53	105	1.94
Garbanzo 4	50	51	101	1.69
Plovdiv 8	60	40	100	1.61
Average	51	51	102	

Quantitative traits of chickpea varieties

The main elements in chickpea productivity are the number of productive nodes per plant, the number of seeds per plant, the seed weight per plant, and the mass of 1000 seeds. These elements are related to accompanying characteristics, such as plant height and the number of basal branches. These elements are related to accompanying characteristics, such as plant height, number of basal branches, foliage, etc. Table 3 presents the results for the studied varieties in terms of the main quantitative traits. Along with the arithmetic averages, the degree of variation of the respective characteristic was also assessed. In terms of biomass/plant weight, the varieties Krajova z Kralovej and Slovak have the highest values (79.33-76.18 g). The plants of FLIP84149 C (72.08 g) and Garbanzo 1 (71.33 g) also had similar values, with an excess over the average value for the group of approximately 25 g. In the remaining accessions, the biomass/plant weight fluctuated within relatively wide limits from 46.27 g (VSP 11) to 69.55 g (Caqui). The calculated coefficient of variation for this trait showed relative stability.

The number of branches was a highly variable indicator, determining the photosynthetic surface area related to plant nutrition, as well as the possibility of obtaining more biomass per unit area when used for fodder. The studied accessions formed an average of 3-4 basal branches per plant. It was found that among the studied varieties there were those with a smaller number of branches (between 2 and 3), such as VSP 11, Irenka, and Plovdiv 8, and accessions with a larger number, such as Alfa Sovhoznyj 14, Dneprovskij 1, Beta, and Garbanzo 1. The Bulgarian varieties Progress and Balkan can also be included in the latter group.

Plant height is an important morphological parameter that is directly related to lodging resistance, leafiness, and direction of use. The most numerous was the group with a height close to the average (61.13 cm), where 12 varieties, or 60% of the collection, were recorded, followed by the groups with short varieties (5, or 25%) and tall varieties (3, or 15%). The lowest were plants of Maskovsky Bagovec (51.20 cm), Garbanzo negro (54.13 cm), and FLIP84149 C (58.13 cm). Irenka (75.37 cm) and Slovak (66.37 cm) were characterized by maximum manifestation of this trait.

To obtain high and stable yields, modern crop cultivation technology recommends the development of varieties with an intensive type. Of great interest are chickpea accessions with a compact bushy shape and a high location of the lower pods (>18 cm). This indicator is defined as an important selection trait that characterizes suitability for mechanized cultivation and contributes to the reduction of seed loss during harvesting. In terms of 1st pod height, it was found that most of the accessions with longer stems (Irenka, Slovak, Progress, Balkan, Sovhoznyj 14, Garbanzo 3, Plovdiv 8, Beta) formed their first pods at a higher height. Similar results were reported by Janghe et al. (2020), as desi-type genotypes developed a longer stem compared to kabuli-type genotypes.

Productivity components

The productivity of chickpea varieties is the main criterion for their evaluation. It is a complex trait composed of the structural elements number of pods, number of seeds, weight of seeds per plant, and mass of 1000 seeds.

In terms of the number of pods/plant, Tadzikskij 10 had the highest value (122.60), followed by Caqui (118.57) and Garbanzo negro (110.00). In the remaining varieties, the number of pods fluctuated within relatively wide limits: from 44-66 in Blanco Lechoso, Garbanzo 3, Garbanzo 1, and Plovdiv 8, to 101-104 in Balkan and Krajova z Kralovej. As a result of experiments conducted in the steppe zone, Burunov et al. (2021) found that the number of beans/plant varied from 20 to 25, and the mass of 1000 seeds from 266 to 326 g. According to the authors, the determinants of chickpea productivity were the number of plants per unit area, the number of seeds per plant, and the mass of 1000 seeds.

The presented results regarding the number of seeds/plant showed that the trait is unstable, with a wide variation, from 42 (for Blanco Lechoso) to 154 (for Garbanzo 4). Garbanzo 4, Caqui, and Tadzikskij 10 formed the highest number of seeds/plants. Varieties VSP 11 (111), Garbanzo negro (128), and Krajova z Kralovej (110) also formed a considerable number of seeds, although with a lower level of superiority compared to the average number for the group (92). The trait seed number was highly variable (31.93%), which indicates a strong dependence on abiotic environmental factors.

In terms of the degree of variation for the trait seed weight/plant, the results were similar to those for the number of seeds/plant. According to the value of CV (18.94%), the variation was average. In some genotypes, the differences were non-essential, and the values were around the average for the group (24.70 g). In terms of seed productivity, Krajova z Kralovej (34.13 g), Beta (33.44 g), and Garbanzo 4 (29.76 g) stand out, in which the weight of seeds was higher than the average (24.70 g). The Caqui variety also had higher seed weight. The Bulgarian variety Balkan, used as a control, can be considered medium productive, with seed weight per plant of 24.97 g.

The mass of 1000 seeds is a characteristic whose variability during the study period was strong (VC=34.33%).

Table 3. Morphological characteristics of chickpea varieties at technical maturity (2023 -2025)

Variety	Weight/ plant	Number of branches	Height/ plant	Height of 1 pod	Number of beans/plant	Number of seeds/plant	Weight of seeds/plant	Weight of 1000 seeds	Pod length
1-Alfa	65.89	3.77	61.07	29.77	83.00	92.10	27.79	310.93	2.70
2-Beta	71.23	3.67	61.93	33.13	82.30	73.95	33.44**	343.91	2.78*
3-Businsky	62.17	3.00	59.50	29.63	81.43	92.60	22.31	228.91	2.23
4-Irenka	50.83	2.77	75.37**	39.47*	66.27	70.80	13.25	175.88	2.10
5-Krajova z Kralovej	79.33*	3.30	61.87	26.97	104.80*	110.73	34.13**	298.86	2.79**
6-Mask. Bagovec	70.00	3.53	51.20	30.43	93.13	99.23	24.15	240.79	2.22
7-Slovak	76.18*	3.10	66.37*	32.50	68.87	79.47	19.04	225.29	2.11
8-FLIP84149 C	72.08	3.07	58.13	24.33	100.07	100.93	26.82	268.82	2.45
9-VSP 11	46.27	2.67	62.60	19.40	92.00	111.73	18.12	172.88	1.64
10- Progres	66.74	3.53	65.30*	36.60	74.97	85.80	25.41	292.22	2.73*
11- Balkan	67.46	3.70	62.53	45.07	101.37	74.90	24.97	338.92	2.44
12- Garbanzo 1	71.33	3.53	58.73	28.33	51.70	54.33	25.23	430.34*	2.54
13-Blanco Lechoso	64.39	3.07	56.70	26.83	44.36	42.21	24.13	577.36**	2.50
14-Caqui	69.55	3.40	60.03	26.50	118.57**	139.47*	28.74	203.86	1.87
15-Garbanzo negro	58.81	3.23	54.13	26.40	110.00*	128.07	25.65	204.12	2.15
16-Tadzikskij 10	55.22	3.07	61.07	25.67	122.60**	139.13*	24.25	177.77	1.87
17-Sovhoznyj 14	57.39	3.77	65.60*	30.30	69.50	92.27	22.48	247.05	2.15
18-Dneprovskij 1	56.03	3.67	59.47	28.93	84.60	89.20	22.18	247.03	2.05
19-Garbanzo 2	61.07	3.30	60.83	28.23	72.27	79.63	25.89	322.23	2.47
20-Garbanzo 3	60.30	3.37	62.83	30.63	49.53	52.67	24.14	458.69*	2.71
21-Garbanzo 4	64.95	3.30	59.57	25.57	97.33	154.10**	29.76	281.84	2.38
22- Plovdiv 8	55.58	2.96	60.10	46.03**	59.97	63.67	21.43	307.00	2.22
Average	63.76	3.31	61.13	35.58	83.12	92.14	24.70	288.85	2.32

$P < 0.05$ **, $P < 0.01$*.

Blanco Lechoso (577.36 g), Garbanzo 3 (458.69 g), and Garbanzo 1 (430.34 g) were distinguished by a greater mass compared to that of all other varieties. Beta, Balkan, and Garbanzo 2 occupied the next positions, respectively, from fourth to sixth, with masses of 343.91 to 322.23 g.

In some varieties, such as Businsky, Maskovsky Bagovec, Slovak, FLIP 84-149 C, Garbanzo negro, Tadzikskij 10, Sovhoznyj 14, Dneprovskij 1, the mass of 1000 seeds was considerably lower than the average value for the group. The results of the present research confirm the studies of Gediya et al.

(2018). They pointed out that the chickpea genotypes can be identified by the morphological characteristics of the seeds and pods. According to the seed size, the authors distinguished 4 groups: with very small seed size (<200 g) - 32 genotypes, with small size (200-250 g) - 100 genotypes, with medium size (260-350 g) - 14 genotypes, and with large size (360-450 g) - 3 genotypes. In the same study, genotypes are divided into three groups based on pod length: small pods (<15 mm), medium pods (15-20 mm), and large pods (>20 mm). The authors believe that these morphological differences are very useful in identifying chickpea genotypes.

Under the present experimental conditions, the pod length was a trait with a low degree of variation (VC=13.78%). The average value did not exceed 23 mm. There was no clearly established dependence between pod number and pod length. In terms of pod length, the varieties Beta, Krajova z Kralovej, Progress, Alfa, and Garbanzo 3 were impressive. Their values were from 2.70 cm to 2.79 cm. As a whole, in the studied collection, accessions with smaller pod sizes predominated. In VSP 11, Caqui and Tadzikskij 10, the pod length did not exceed 19 mm. In a similar investigation, Petrova and Angelova (2017) evaluated the main characteristics of chickpea genotypes. They found a large diversity and range of variation of quantitative traits, suggesting broader possibilities for their use.

The authors have indicated a low coefficient of variation for flowering duration and a high one for almost all other indicators, such as number of seeds/plant, seed weight/plant, and mass of 1000 seeds, which is also confirmed in the study conducted. Arriagada et al. (2022) and Mir et al. (2019) believed that in the future, the breeding of new cultivars should be based on a complete phenotypic and genetic description of the materials that will be used as parental forms in breeding programs.

This could be based on new phenotyping techniques as well as characterization of aboveground parts and root system architecture under different growing conditions.

Seed quality parameters

Chickpea seeds are distinguished by a favorable chemical composition, which is characterized by high bioavailability for the body (Donskaya and Bobkov, 2015). In the present experiment, the determination of basic parameters, such as crude protein, crude fiber, calcium, and phosphorus, was carried out. The results showed a statistically significant influence of the genotype factor on the expression of the crude protein and calcium content. For the phosphorus content, the influence of the environmental factor was reliable (Table 4).

The average value for crude protein content was 19.32% (Table 5). The variation of this parameter was from 17.56% for Garbanzo 4 to 21.27% for FLIP 84-149 C. Some varieties, such as Caqui, Garban negro, Tadzikskij 10, Dneprovskij 1, Garbanzo 2, and Garbanzo 3, had very low crude protein content (17-18%). Nine accessions, including the Bulgarian varieties, had protein content between 19% and 20%. In addition to FLIP 84-149, high protein content was also found in Grabonzo 1 and Alfa. They can be used in future breeding programs as high-protein sources.

A metric for assessing the effectiveness of seed production in terms of both quantity and quality is seed yield. The genotype, crop age, agricultural practices used, the presence of plant disease agents in the soil and plant material, and the capacity to absorb nutrients all have a substantial impact on seed yield (Božović et al., 2020; Popović et al., 2013; Lakić et al., 2022; Dimitrijević et al., 2024; Georgieva et al., 2025a; 2025b; Dimitrova et al., 2026).

The average values of crude fiber in VSP 11, Caqui, Garban negro, and Tadzikskij 10 were the highest in the studied group and almost equal (7.04-7.87%). The Bulgarian variety Balkan had a crude fiber content of 2.54%, which is considerably below the group average (3.75%). The situation was similar for 14 of the varieties, characterized by a crude fiber content of less than 3%. According to Stallknecht et al. (2006), chickpeas are a good source of protein and carbohydrates, which together constitute approximately 80% of the total dry weight of the grain. The authors reported a content of CP from 13 to 33% and of CF from 40 to 55%.

Table 4. Analysis of variance (ANOVA) for seed quality parameters in chickpea varieties

Source of variation	DF	MS			
		CP	CF	Ca	P
Environment (Year)	21	30.46**	1082.96	0.001	0.002*
Genotype (Variety)	2	5.084**	1026.70	0.007**	0.0006
Total	23				

P < 0.05 **, P < 0.01*; CP - crude protein, CF - crude fibers.

Table 5. Biochemical composition of seeds in chickpea varieties

Variety	CP	CF	Ca	P
Alfa	20.79	2.12	0.18	0.483
Beta	20.37	2.27	0.13	0.485
Businsky	19.46	2.25	0.12	0.478
Irenka	20.68	4.42	0.14	0.522
Krajova z Kralovej	20.60	2.69	0.15	0.488
Maskov Bagovec	17.86	2.70	0.47	0.490
Slovak	19.00	3.18	0.13	0.475
FLIP 84-149 C	21.27	2.93	0.11	0.517
VSP 11	20.66	7.29	0.14	0.468
Progres	20.12	2.90	0.20	0.505
Balkan	20.42	2.54	0.15	0.479
Grabonzo 1	21.18	2.70	0.15	0.512
Blanco Lechoso	20.08	2.76	0.16	0.486
Caqui	17.57	7.70	0.15	0.488
Garban negro	17.88	7.04	0.16	0.490
Tadzikskij 10	17.84	7.87	0.16	0.487
Sovhoznyj 14	18.16	6.43	0.15	0.485
Dneprovskij 1	17.84	3.44	0.12	0.506
Garbanzo 2	17.74	2.58	0.13	0.480
Garbanzo 3	18.41	2.28	0.11	0.482
Garbanzo 4	17.56	2.37	0.13	0.488
Plocdiv 8	19.50	2.14	0.15	0.496
Average	19.32	3.75	0.16	0.49
$LSD_{0.05}$	1.34	0.91	0.04	0.03

CP - Crude protein, CF - Crude fibers.

According to results obtained by Donskaya and Bobkov (2015), the protein content in the seeds fluctuated of 12.6 to 30.5%. According to the authors, the protein content in chickpea seeds depends on both the plant genotype and environmental conditions. Bulyntsev and Balashov (2010) expressed the opinion that chickpeas respond strongly to environmental conditions, leading to changes in their chemical composition. In hot and dry climates with limited rainfall, seeds accumulate more protein than those in areas with a wetter climate and lower temperatures. Donskaya and Bobkov (2015) noted that despite the availability of chickpea genotypes with high protein content, very little progress has been made in crop breeding aimed at developing high-protein varieties.

The average content of Ca in the present experiment was 0.16%, varying from 0.11 to 0.47%. Of particular interest is the variety Maskovsky Bagovec, which had the highest calcium content (0.47%), many times exceeding that of the other varieties. A significant excess was also observed in Progress (0.20%) and Alfa (0.18%), which occupy second and third positions, respectively.

The data on phosphorus content did not show unidirectionality compared to the previous indicator. The average percentage of phosphorus content for the study period was 0.49%. The seeds of four varieties, namely

Irenka (0.522%), FLIP 84-149 C (0.517%), Grabonzo 1 (0.512%), and Dneprovskij 1 (0.506), regardless of the year factor, demonstrated a high phosphorus content. The phosphorus content was comparatively lower in Businsky (0.478%), Slovak (0.475%), and Balkan (0.479%).

CONCLUSIONS

Based on a comparative evaluation of 22 chickpea varieties for a complex of agronomic traits under the conditions of Central Northern Bulgaria, the following conclusions can be drawn:

Genotypes Irenka (75.37 cm) and Slovak (66.37 cm) were distinguished by favorable plant architecture, characterized by greater plant height, higher first pod position (32–39 cm), and a sufficient number of basal branches, making them suitable for mechanized harvesting.

The variety VSP 11 was characterized by the shortest growing season (89 days). The medium-early group included Maskovsky Bagovec, FLIP 84-149 C, Garbanzo negro, Tadzikskij 10, and Dneprovskij 1, as well as the Bulgarian variety Plovdiv 8.

Varieties Krajova z Kralovej (34.13 g), Beta (33.44 g), Garbanzo 4 (29.76 g), and Caqui (28.74 g) were distinguished by high seed weight per plant. Blanco Lechoso (577.36 g), Garbanzo 3 (458.69 g), and Garbanzo 1 (430.34 g) can be defined as large-seeded genotypes (mass > 400 g).

High variability (CV > 20%) was observed for first pod height (23.07%), number of pods per plant (26.28%), number of seeds per plant (31.93%), and 1000-seed weight (34.33%). Moderate variability (CV = 10-20%) was recorded for seed weight per plant (18.94%), pod length (13.78%), and biomass weight per plant (12.98%), while low variability (CV <10%), indicating greater stability, was found for plant height (7.72%) and number of basal branches (9.63%).High crude protein content was demonstrated by FLIP 84-149 (21.27%), Grabonzo 1 (21.18%), and Alfa (20.79%), highlighting their potential as valuable genetic resources for the development of high-protein chickpea varieties.

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REFERENCES

Arriagada, O., Cacciuttolo, F., Cabeza, R.A., Carrasco, B., Schwember, A.R., 2022. *A Comprehensive Review on Chickpea (Cicer arietinum L.) Breeding for Abiotic Stress Tolerance and Climate Change Resilience*. Int. J. Mol. Sci., 23, 6794. https://doi.org/10.3390/ijms23126794

Bar-El Dadon, S., Abbo, S., Reifen, R., 2017. *Leveraging traditional crops for better nutrition and health - The case of chickpea.* Trends Food Sci. Technol., 64: 39-47.

Baytarakova, K.Zh., and Kudaibergenov, M.S., 2021. *Election of chickpea cultivars based on economically valuable characteristics and the results of structural analysis.* Proceedings of the International scientific-practical conference «Actual problems of agro-science in the context of adaptation to global climate change» devoted to the 75th anniversary of the Doctor of Agricultural Sciences, Republic of Kazakhstan, 17-18 June 2021, Almalzbak: 103-104.

Božović, D., Živanović, T., Popović, V., Tatić, M., Gospavić, Z., Miloradović, Z., Stanković, G., Dokić, M., 2020. *Assessment stability of maize lines yield by GGE-biplot analysis*. Genetika, 50(3): 755-770. DOI: 10.2298/GENSR1803755B

Bulyntsev, S.V., and Balashov, A.V., 2010. *Genetic Resources of World Chickpea Collections*. Vestnik RASKhN, 6: 42-45.

Burunov, A.N., Vasin, V.G., Vasin, A.V., 2021. *The productivity of chickpea varieties when using fertilizers and growth stimulants in the dry steppe zone of the middle Volga region.* Legumes and Groat Crops, 1(37): 20-29. j_zbk_2021_1-020-029.pdf (vniizbk.ru)

Dehal, I.B., Kalia, R., Kumar, B., 2016. *Genetic estimates and path coefficient analysis in chickpea under normal and late sown environments.* Legume Research, 39(4): 510-516.

Dimitrova, S., Georgieva, N.A., Kosev, V.I., Popović, V.M., Filipović, V., Bošković, J., Jovanović-Todorović, M., 2026. *Cicer arietinum - Importance, Distribution, Use and breeding guidelines*. Romanian Agricultural Research, 43: 143-155. https://doi.org/10.59665/rar4314

Dimova, D., and Marinkov, E., 1999. *Experimental work with biometrics*. Sofia, Zemizdat.

Dimitrijević, S., Milić, M., Buntić, A., Dimitrijević-Branković, S., Filipović, V., Popović, V., Salamon, I., 2024. *Spent coffee grounds, plant growth promoting bacteria, and medicinal plant waste: The biofertilizing effect of high-value compost.* Sustainability, 16(4), 1632.

Donskaya, M.V., and Bobkov, S.V., 2015. *Protein content in seeds of collection samples of chickpea*. Legumes and Groat Crops, 1(13): 53-55.

Farahani, S., Maleki, M., Mehrabi, R., Kanouni, H., Scheben, A., Batley, J., Talebi, R., 2019. *Whole Genome Diversity, Population Structure, and Linkage Disequilibrium Analysis of Chickpea (Cicer arietinum L.) Genotypes Using Genome-Wide DArTseq-Based SNP Markers.* Genes, 10, 676.

Fedotov, V.A., Stolyarov, O.V., Demchenko, N.I., 2004. *Chickpea (Cicer arietinum)*. Monography, Voronezh, VGU Publishing House, 256 pp.

Gediya, L.N., Patel, D.A., Kumar, D., Vekariya, K.J., Nayak, J.J., 2018. *Characterization of chickpea genotypes based on morphological traits*. Journal of Pharmacognosy and Phytochemistry, 7(4): 3008-3015.

Georgieva, A.N., Kosev, V., Popović, V., 2025a. *Prospects for breeding and heterosis studies for yield and yield components in white lupine hybrids (Lupinus. albus L.).* Genetika, Belgrade, 57(1): 97-112. https://doi.org/10.2298/GENSR2501097G

Georgieva, A.N., Kosev, I.V., Popović, V.M., Golijan Pantović, J., Ikanović, J., 2025b. *Responses of white lupine accessions to environmental stresses under organic cultivation*. Genetika, 57(3): 407-424. https://doi.org/10.2298/GENSR250328003A

Ilin, S., Popović, V., Đukić, V., Živančev, D., Karić, L., Papler, D., Pogačnik, M., Znidarcic, D., 2025. *Soybean [Glycine max (L.) Merr.] Seed Yield and Seed Oil Content as Influenced by Different Environmental Conditions and Genotypes*. Romanian Agricultural Research, 42: 313-332. https://doi.org/10.59665/rar4227

Janghe, D.K., Kumar, K., Sunil, R., Chhabra, A.K., 2020. *Analysis of genetic diversity, characterized and evaluation of elite chickpea genotypes (Cicer arietinum L.).* Int. J. Curr. Microbiol. App. Sci., 9(1): 199-209. https://doi.org/10.20546/ijcmas.2020.901.023

Kalashnikova, S.V., and Tertichnya, T.N., 2005. *Chickpeas - a promising raw material in the production of confectionery products.* Food Technology, 2-3, 110.

Katkani, D., Babbar, A., Upadhyay, S., Goyal, V., 2022. *Computation of Genetic Variability and Divergence Analysis in Advance Breeding Lines of Chickpea*. Biological Forum - An International Journal, 14(2): 611-617.

Kaur, R., and Prasad, K., 2021. *Nutritional characteristics and value-added products of Chickpea (Cicer arietinum) - A review*. J. Postharvest Technol., 9: 1-13.

Kuzmova, K., 2002. *World agro-climatic analogues of Bulgaria on the conditions of cultivation of peas.* Jubilee session "120 years of agricultural science in Sadovo": 113-118.

Lakić, Ž., Popović, V., Ćosić, M., Antić, M., 2022. *Genotypes variation of Medicago sativa (L.) seed yield components in acid soil under conditions of cross - fertilization*. Genetika, 54(1): 1-14.

Maphosa, L., Richards, M.F., Norton, S.L., Nguyen, G.N., 2020. *Breeding for Abiotic Stress Adaptation in Chickpea (Cicer arietinum L.): A Comprehensive Review*. Crop. Breed. Genet. Genom. Breeding for Abiotic Stress Adaptation in Chickpea (*Cicer arietinum* L.): A Comprehensive Review (hapres.com), 2, e200015.

Mihoariya, M., Tiwari, S., Yadav, R.K., Asati, R., Solanki, R.S., Tiwari, P.N., Chauhan, Sh., Tripathi, N., Tripathi, M.K., 2023. *Genetic variability and diversity analysis for yield and its associated traits in chickpea (Cicer arietinum L.).* Current Journal of Applied Science and Technology, 42(16): 17-33.

Mir, R.R., Reynolds, M.P., Pinto, F., Khan, M.A., Bhat, M.A., 2019. *High-throughput phenotyping for crop improvement in the genomics era.* Plant Sci., 282: 60-72.

Novikov, A.V., 2021. *Optimization of chickpea cultivation techniques in the dry steppe zone of the Middle Volga region*. Dissertation, Samara State Agrarian University, 166 pp.

Petrova, S., and Angelova, S., 2017. *Characteristics of plant accessions faba bean (Vicia faba), vetching (Lathyrus sp.) and chickpeas (Cicer arietinum) with local origin*. Plant Science, 50: 47-49.

Popović, V., Malesević, M., Miladinović, J., Marić, V., Živanović, Lj., 2013. *Effect of agroecological factors on variations in yield, protein and oil contents in soybean grain*. Romanian Agricultural Research, 30: 241-247.

Rajičić, V., Milivojević, J., Popović, V., Branković, S., Đurić, N., Perišić, V., Terzić, D., 2019. *Winter wheat yield and quality depending on the level of nitrogen, phosphorus and potassium fertilization*. Agriculture and Forestry, 65(2): 79-88. DOI: 10.17707/AgricultForest.65.2.06

Sadigova, M.K., Rozanov, A.V., Karpova, L.I., 2010. *Improving the nutritional value of bakery products with nutraceutical additives by optimizing their recipes*. Bulletin of the Saratov State Agrarian University, 11: 54-59.

Sandev, S., 1979. *Chemical methods for feed analysis.* Zemizdat, Sofia.

Sharma, S., Tripathi, M.K., Tiwari, S., Solanki, R.S., Chauhan, S., Tripathi, N., Dwivedi, N., Kandalkar, V.S., 2023. *The Exploitation of genetic variability and trait association analysis for diverse quantitative traits in bread wheat (Triticum aestivum L.). urrent*. Journal of Applied Science and Technology, 42(8): 19-33.

Stallknecht, G., Gilberston, K.M., Carlson, G.R., Eckhoff, J.L., Kushnak, G.D., Sims, J.R., Wescott, M.P., Tejera, N., Soussi A.M., Luch, C., 2006.

Physiological and nutritional indicators of tolerance to salinity in chickpea plants growing under symbiotic conditions. Env. Exp. Bot., 58(1-3): 17-24.

Suleimanova, G.A., Sapakhova, Z.B., Kalibayev, B.B., 2021. *Overview of major diseases of leguminous crops for the purpose of gene pool screening in the conditions of the Almaty region*. Proceedings of the International scientific-practical conference «Actual problems of agro-science in the context of adaptation to global climate change» devoted to the 75th anniversary of the Doctor of Agricultural Sciences, Republic of Kazakhstan Meiirman Galiolla, 17-18 June 2021: 295-297.

Taskinbayeva, R.Zh., Esymbekova, M.A., Ydyrys, A.A., Baitarakova, K.Zh., 2022. *Formation of an active collection of chickea (Cicer L.) for adaptability and tolerance breeding in the conditions of the south-east of Kazakhstan*. Scientific and Production Journal Cereal and Grain Cultures, 2(42): 74-81.
DOI: 10.24412/2309-348X-2022-2-74-81

Thudi, M., Chitikineni, A., Liu, X., He, W., Roorkiwal, M., Yang, W., Jian, J., Doddamani, D., Gaur, P., Rathore, A., Samineni, S., Saxena, R., Xu, D., Singh, N., Chaturvedi, S., Zhang, G., Wang, J., Datta, S., Xu, X., Varshney, R., 2016. *Recent breeding programs enhanced genetic diversity in both desi and kabuli varieties of chickpea (Cicer arietinum L.).* Sci. Rep., 6, 38636.

Toker, C., Berger, J., Eker, T., Sari, D., Sari, H., Gokturk, R.S., Kahraman, A., Aydin, B., von Wettberg, E.J., 2021. *Cicer turcicum: A New Cicer Species and Its Potential to Improve Chickpea.* Front. Plant Sci., 12, 587.

Ugrenović, V., Popović, V., Ugrinović, M., Filipović, V., Mačkić, K., Ljubičić, N., Popović, S., Lakić, Ž., 2021. *Black oat (Avena strigosa schreb.) ontogenesis and agronomic performance in organic cropping system and Pannonian environments*. Agriculture, 11(1): 1-14.
DOI: 10.3390/agriculture11010055

Uyeturk, A.S., Kayan, N., Togay, N., 2023. *Effects of different soil tillage methods, phosphorus fertilizer doses and bacteria inoculation on yield and yield components in chickpea (Cicer arietinum L.).* Romanian Agricultural Research, 40: 317-325.
https://doi.org/10.59665/rar4030