Plant and Soil Science

Journal homepage: https://agriculturalscience.com.ua/en
*Plant and Soil Science, 14(3), 97-110*
Received: 31.03.2023 Revised: 04.07.2023 Accepted: 11.08.2023

UDC 635.657:[581.522.4+581.95]061.62 DOI: 10.31548/plant3.2023.97

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# Biological, morphological and biochemical features of seeds of introduced genotypes of *Cicer arietinum* L.

**Abstract.** The research relevance is determined by the need to develop modern scientific and practical principles of involving little-known, rare, and newly created plant genotypes in the introduction process. This will help to warn of a possible phytoproduct crisis caused by climate change and rapid population growth on the planet. The research aims to determine the morphological characteristics and biochemical features of *Cicer arietinum* seeds for improving the germplasm of legumes and

**Suggested Citation**:

Rakhmetov, D., Bondarchuk, O., Rakhmetova, S., Rashydov, N., & Kutsokon, N. (2023). Biological, morphological and biochemical features of seeds of introduced genotypes of *Cicer arietinum* L. *Plant and Soil Science,* 14(3), 97-110. doi: 10.31548/plant3.2023.97.

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conducting further breeding and biotechnological research. The comparative morphological method was used for seeds of introduced plant genotypes from different regions of origin. The material for the study was 9 genotypes of *Cicer arietinum* originating from Australia, Afghanistan, Azerbaijan, and Ukraine, which were grown in experimental plots of the M.M. Gryshko National Botanical Garden. Morphometric parameters and some biochemical properties of plant seeds were studied depending on genotypic characteristics. Field, laboratory, and methods of analysis of variance and statistical evaluation of average data were used using Microsoft Excel (2010). In the course of the research, it was found that all introduced genotypes are characterised by high quantitative and qualitative indicators of seeds. In terms of linear seed dimensions (length to width ratio), the sample CAAFGK-1 was particularly distinguished – 17.12×14.38 mm, and in terms of weight of 1000 seeds CATADJK-1 – 584.5 g. Biochemical studies have shown that the highest amount of absolute dry matter was accumulated in the seeds of *C. arietinum* samples – CAAFGD-2, CAAFGK-1, CATADJD-2 and CATADJK-1 (from 89.04 to 89.68%). The level of total sugars was dominated by the samples of *C. arietinum* genotypes CATADJK-1 – 9.37%, and the accumulation of phosphorus was dominated by CAAZEUR-2 – 1.43%. The biochemical composition of plants makes it possible not only to characterise their value in terms of food crops but also to determine the most plastic genotypes to environmental factors. Thus, the results obtained indicate the prospects of using certain genotypes of *C. arietinum* as a starting material for breeding and biotechnological research and the creation of new plant forms, which will help to expand the range of highly productive chickpea genotypes in the northern regions of Ukraine

**Keywords:** climate; chickpea; germplasm; morphological characteristics; seed composition

## INTRODUCTION

The *Fabaceae* (*Leguminosae*) family is one of the largest in the plant kingdom and includes more than 500 genera and about 17,100 species distributed almost all over the world. A large number of representatives are a valuable source of raw materials to meet the needs of the population, as well as an integral component in the proper functioning of natural ecosystems. In this regard, mankind has naturalised and cultivated several well-known species for thousands of years (including beans, beans, peas, soybeans, etc.), among which the representatives of the genus *Cicer* deserve special attention.

Chickpea, along with other pulses, is an extremely valuable and promising crop worldwide, with an area under cultivation of over 17.8 million hectares and a production of 17.2 million tonnes of seeds (Amina *et al.*, 2020; Durdane, 2022). In Ukraine, 70 thousand hectares are allocated for chickpea cultivation (Shcatula & Votyk, 2020). For example, global soybean acreage is 120 million hectares with a harvest of more than 300 million tonnes (FAOSTAT, 2021), while according to the Ministry of Agrarian Policy and Food of Ukraine (2022), soybean acreage in Ukraine is about 1,213 thousand hectares.

F. Boukid (2021) and S.E. Mathew *et al.* (2022) indicate that the protein content of chickpea seeds ranges from 17-30% of the absolute dry weight. In addition, they noted a high content of carbohydrates, vitamins, and minerals. Chickpea plays an important role in agriculture by increasing soil fertility through biological nitrogen fixation (Gediya *et al.*, 2019; Alok *et al.*, 2020). A global collection of approximately 100,000 accessions of *C. arietinum* is held in 120 national and international genebanks in 64 countries. In general, varietal resources include about 400 taxa (Piergiovanni, 2022), of which 38 varieties of Ukrainian selection are listed in the State register of varieties suitable for distribution in Ukraine (2022).

Ukraine is one of the largest agricultural countries supplying the world market with a significant number of agricultural products, including pulses. Its physical and geographical location allows for a further increase in pulses production through the introduction of plant genotypes that are not common in this area, such as *C. arietinum*. Therefore, enrichment of the gene pool and comprehensive introduction and breeding research is important in solving the problem of increasing the productivity and production of this crop, as well as providing the food market with the necessary raw materials.

Depending on the habitat, the morphological traits of any plant species vary. The ability of plants to form differentiated phenotypes that depend on environmental conditions is called phenotype modification or phenotypic plasticity (Khanna *et al.*, 2022). Seeds are the initial stage of plant ontogenetic development, so at this stage, it is possible to study the ability of a plant organism to form several different, relatively appropriate phenotypes in many environments (La *et al.*, 2022). In general, phenotypic plasticity, as a response to environmental factors, can be reflected both in the number of seeds produced and in their size among different populations of the same species due to differences in habitat (Zerfu *et al.*, 2021; Mehmetoglu *et al.*, 2022). In this case, the seeds of *C. arietinum* plants are also characterised by wide polymorphism. There are three groups of chickpeas in the world: Kabuli, Desi, and Bombay. Kabuli types have scoop-shaped, large, cream-coloured seeds, Desi types are angular, small, and dark in colour, Bombay is also dark in colour but larger than the Desi variety (Nisa *et al.*, 2020). Mobilising plants from different centres of origin and focusing on intraspecific seed variation is important for preserving germplasm of valuable genotypes in collection funds and creating varieties and forms with specified parameters (Mohanty *et al.*, 2022).

In this regard, the study aimed to determine the biological and morphological features and some structural, functional, and biochemical compounds in the seeds of different chickpea (*Cicer arietinum* L.) genotypes introduced in the M.M. Gryshko National Botanical Garden of the National Academy of Sciences (NAS) of Ukraine.

## MATERIALS AND METHODS

The study was carried out in 2020-2021 at the experimental plots of the Department of Cultural Flora of the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine, located at 50°24′45″N, 30°33′44″E, with an area of about 129 ha (Fig. 1).

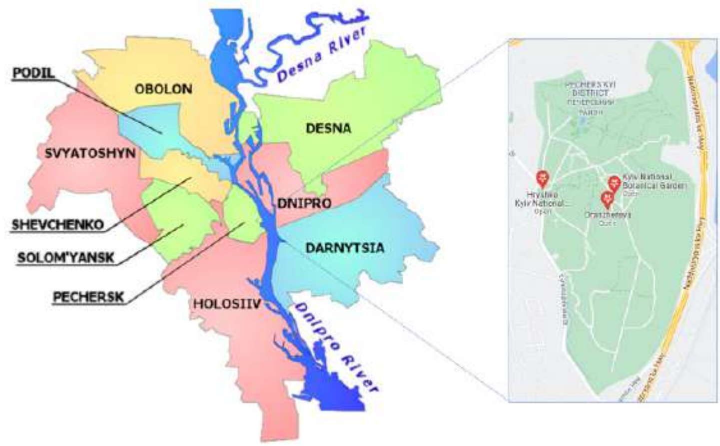


**Figure 1.** Map of the location of the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine

The territory of the introduction plots is represented by grey forest podzolic soils. The depth of the arable layer is 20-22 cm. The humus content of the soil is 3.26%, pH is 6.7, nitrogen content is 98 mg/kg, phosphorus is 373 mg/kg, and potassium is 66 mg/kg.

This study was carried out within the framework of the National Research Foundation of Ukraine project "Influence of stress factors on the synthesis of proteins with prion properties in plants". Different genotypes of *C. arietinum* plants collected in the collection fund of the Department of Cultivated Flora of the M.M. Gryshko National Library of the National Academy of Sciences of Ukraine were used. Plants were grown in the open field in small plots (6 replications). At the end of the vegetation phase, the aerial part was cut off and threshed on a grain thresher. The resulting seeds were dried and randomly selected for further analysis. The most typical samples for each of the involved genotypes were selected for photographic recording.

The morphological description of the seed surface microsculpture of *C. arietinum* and *G. max* plants was performed according to the Illustrated guide to the morphology of flowering plants (Zyman *et al.*, 2012). The biometric and comparative methods of determining their external and internal features were also used, along with photographic recordings in length, width and cross-section using a SIGETA Expert 10-300x 5.0Mpx electric USB microscope (China) and a Canon 400 D digital camera (Japan). Linear dimensions were recorded using a Generic electronic digital calliper (China) and a Xiaomi Duka SD measuring tape (China). The weight of 1000 seeds were estimated on an AXIS ANG 200C electronic analytical balance (Poland) in ten replicates according to the international rules for seed testing (1999).

Based on the data obtained from the archives of weather monitoring of the Central Geophysical Observatory (2023), a comparative assessment of the weather and climatic conditions of the study area was made with the average long-term indicators (Fig. 2). During the growing season of 2020-2021, it was shown that the average monthly air temperature, starting in June, had a significant deviation from the norm in the direction of a significant increase.

Precipitation is essential for plant growth, development, and productivity. In 2020 and 2021, total precipitation was significantly above normal only in May and October, and in 2021 – only in May. For all other months of the growing season, the amount of precipitation was significantly below normal. The studied *C. arietinum* plants experienced a significant moisture deficit and high temperatures during a significant part of the growing season. Under these conditions, the plants successfully vegetated and provided high growth and productive performance.

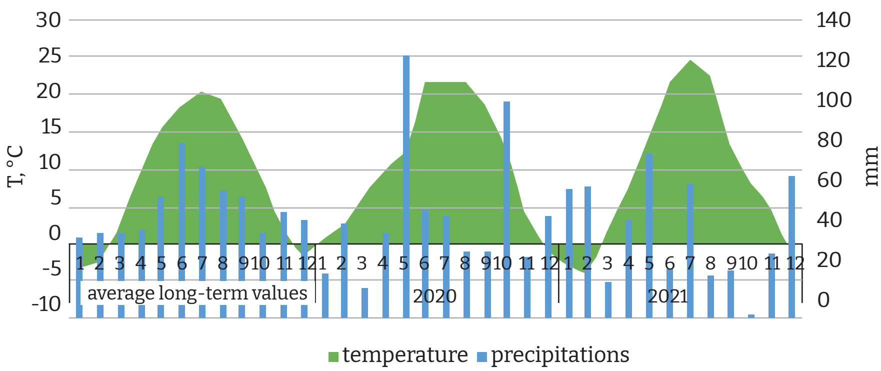


**Figure 2.** Dynamics of average monthly temperatures and precipitation (2020-2021) compared to long-term averages

Statistical data processing was carried out using Microsoft Excel 2010 (Data Analysis package). The minimum, maximum, mean, standard deviation and coefficient of variation were used to express the data obtained. The study was conducted following the requirements of the Convention on Biological Diversity (1992).

## RESULTS AND DISCUSSION

The effectiveness of breeders' creation of new competitive varieties with high levels of productivity, manufacturability, product quality, and adaptability are based on the correct selection of source material, which should be based on genetic resources that have been comprehensively studied and structured into appropriate collections.

The value of the selected genotypes is that they have different origins: Australia – *C. arientinum* ('Tyson'); Afghanistan – *C. arietinum* (CAAFGK-1 and CAAFGD-2); Azerbaijan – *C. arietinum* (CAAZEMR-1 and CAAZEUR-2); Tajikistan – *C. arietinum* (CATADJK-1 and CATADJD-2); Ukraine – *C. arietinum* (CAUKR and CAOCHL). (Fig. 3).


**Figure 3.** Seeds of the studied genotypes *Cicer arietinum* mobilised to the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine

**Note:** 1 – CAAFGK-1, 2 – CAAFGD-2, 3 – CAAZEMR-1, 4 – 'Tyson', '5 – CAOCHL, 6 – CAUKR, 7 – CAAZEUR-2, 8 – CATADJK-1, 9 – CATADJD-2, 10 – *Glycine max*, 'Soniachna' (for comparison)

The seed size of any legume crop is important in determining its market value and is also an important parameter for breeders who also rely on these parameters (Upadhyaya *et al.*, 2006; Houasli *et al.*, 2021). Therefore, we evaluated seeds by length, which is rarely found in the literature. The analysis of seeds by length allowed us to identify several differences between the involved genotypes and, based on the data obtained, to divide them into length groups. Thus, CAAFGK-1 has the largest seed length of 17.12 mm. The genotypes CAUKR, CATADJD-2, and CAAZEMR-1 were characterised by slightly smaller sizes (from 15.26 to 15.91 mm). 'Tyson', CAAZEUR-2, CAAFGD-2, CAOCHL, and CATADJK-1 were characterised by the shortest length (12.51 to 14.97 mm) (Fig. 4). In a study by O. Legesse *et al.* (2022) the linear dimensions of *C. arietinum* seeds (including length) on average range from 8.89 to 9.82 mm, which is significantly smaller than those of the introduced genotypes in the National Botanical Garden. This may indicate that the growing conditions are favourable for large seed sizes.

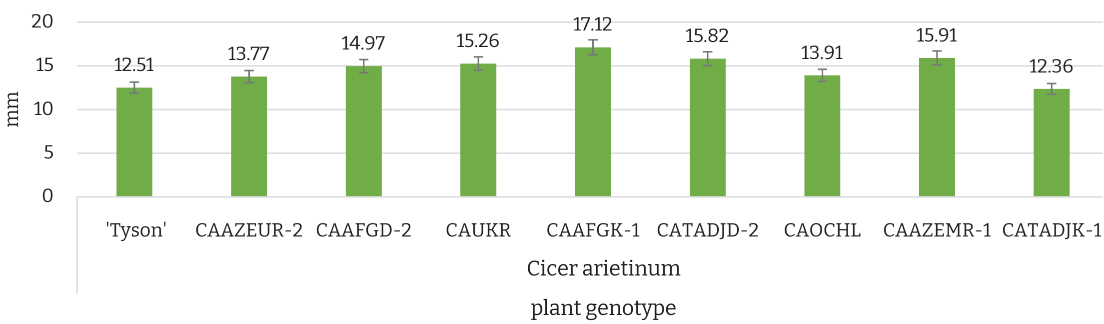


**Figure 4.** Seed length of *Cicer arietinum* depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

The price of chickpeas depends on the quality of the product. The main criterion for chickpeas is grain size. Chickpeas with a grain diameter of 8 mm or more are valued (Kivrak *et al.*, 2020). Today, little attention is paid to the linear dimensions of the seeds, and only their weight is studied. In their research, M. Kaya *et al.* (2008) reported that the maximum size of the studied genotypes ranged from 7 to 9 mm. Evaluation of seeds by width also revealed that CAAFGK-1 (14.38 mm) had the highest value among other introduced genotypes. CAAFGD-2, CAUKR, CATADJD-2, and CAAZEMR-1 were characterised by smaller seed width (from 13.47 to 13.83 mm). The smallest seed width was in genotypes CATADJK-1, 'Tyson', CAAZEUR-2, CAOCHL (from 10.47 to 12.02 mm) (Fig. 5). Given the rather high performance, all introduced genotypes are promising for further breeding research and widespread use in agriculture.

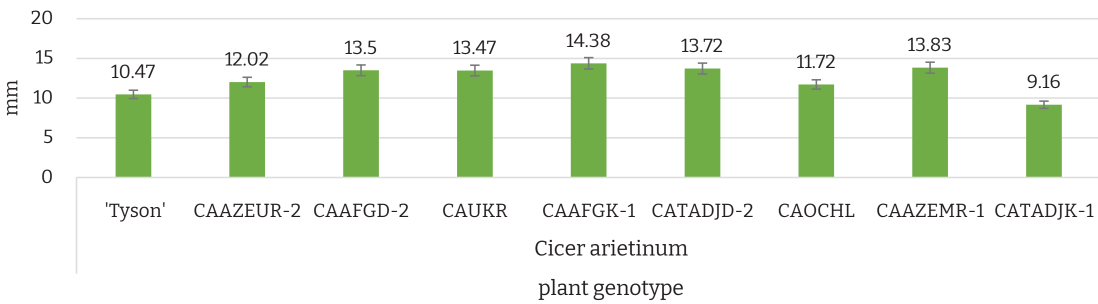


**Figure 5.** Seed width of *Cicer arietinum* depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

The weight of 1000 seeds as one of the main elements of the yield structure varies depending on genotypic characteristics and growing conditions. As indicated by O. Legesse *et al.* (2022) and A.A. Igolkina *et al.* (2023), the weight of 1000 seeds ranges from 284.7 to 500.1 g for C. arietinum genotypes. In these studies, the highest values were recorded for *C. arietinum* seeds of CATADJK-1 – 584.5 g of Tajik origin and CAAFGK-1 – 566.0 g of Afghan origin. The average values were provided by the genotypes CAAFGD-2, CAUKR, CATADJD-2, and CAAZEMR-1 (from 399.5 to 485.0). CAOCHL seeds had the lowest weight of 200.5 g. Thus, considering the whole complex of evaluated morpho-physical parameters of seeds and comparative analysis with available literature data, we can make a preliminary conclusion about significant prospects of their introduction into breeding practice for the creation of new varieties and hybrids and introduction of *Cicer arietinum* genotypes into agricultural production in Ukraine (Fig. 6).

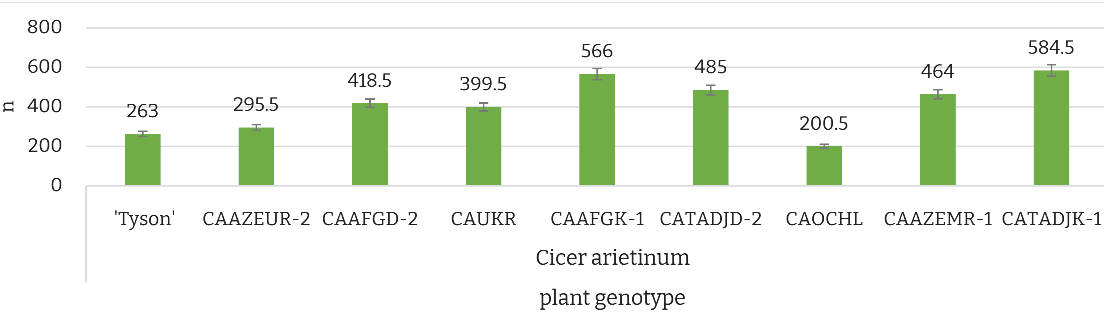


**Figure 6.** Mass of 1000 *Cicer arietinum* seeds depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

The vast majority of morphological studies are aimed at dividing chickpea genotypes into three groups according to well-defined external features (Kabuli, Desi, Bombay) (Milan-Noris *et al.,* 2018; Mazur *et al.,* 2021). Given this, among the introduced genotypes in the NBS, there are clearly defined Kabuli and Desi groups. In this regard, it was necessary to trace the heterogeneity of morphological traits within each group, since this issue is not paid attention to in the literature, but these results can be successfully used in the selection of genotypes. Therefore, we conducted micromorphological studies of the seed characteristics of these representatives. It was found that the introduced genotypes have several differences: in the shape and surface of the seed; the colour of the seed coat and scar; colour and structure of the endosperm. Thus, the analysis resulted in the following groups of genotypes based on seed shape: elliptical – CAAFGK-1; round – CAAFGD-2, CAAZEUR-2, CATADJD-2; heart-shaped – CAAZEMR-1, 'Tyson', CAOCHL, CAUKR, CATADJK-1. According to the colour of the seed coat, the following were distinguished: white – CAAFGK-1, CAAFGD-2, CAAZEMR-1, CAUKR, CAAZEUR-2, CATADJK-1, CATADJD-2; black – 'Tyson', CAOCHL. In the samples of plants CAAFGK-1, CAAZEMR-1, CAUKR, and CATADJK-1, the seed surface is tuberous, angular – in genotypes 'Tyson', CAOCHL, in samples CAAFGD-2, CAAZEUR-2 – wrinkled. Regarding the features of the seed scar, it should be noted that in all the studied representatives it is located on the seed surface (slightly convex), in CAAFGK-1, CAAFGD-2, CAAZEMR-1, CAUKR, CAAZEUR-2, CATADJK-1, CATADJD-2 plants it has a light brown and sometimes yellowish colour, and in 'Tyson' and CAOCHL representatives it is black with an anthracite sheen.

As for the colour and structure of the endosperm, the cross-section of seeds revealed several differences. In the genotypes CAAFGK-1, CAAFGD-2, CAAZEMR-1, 'Tyson', CAOCHL, and CATADJD-2, the endosperm is hard, dense, and does not split into halves along the seed suture when split. In the other representatives of CAUKR, CAAZEUR-2, and CATADJK-1, the seed easily splits into two halves, characteristic of traditional legumes, along the seed suture. According to the colour of the endosperm, the seeds of the introduced genotypes are divided into the following groups: whitish yellow with a yellow surrounding near the seed coat – CAAFGK-1, CAUKR, CATADJK-1; yellow – CAAZEMR-1, 'Tyson', CAOCHL, CAAZEUR-2, CATADJD-2; whitish or pale – CAAFGD-2 (Fig. 7).

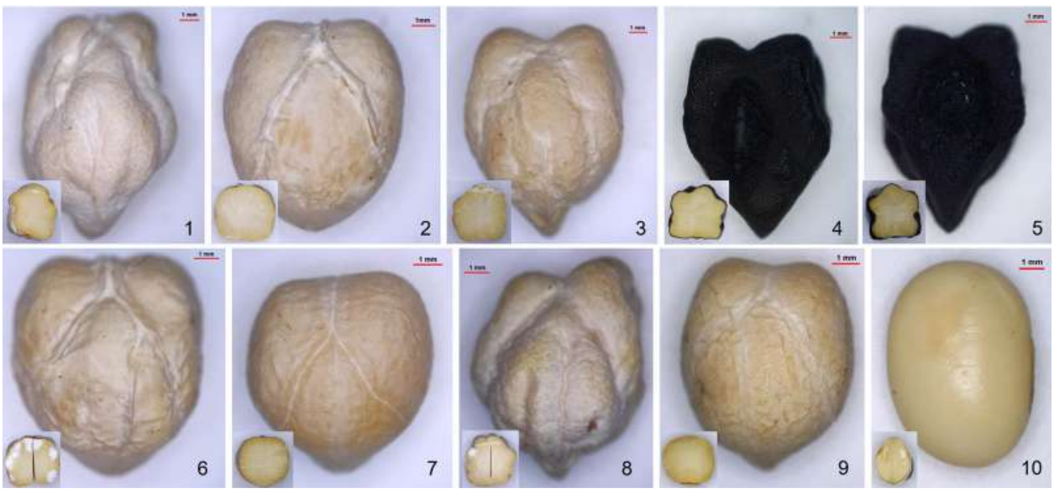

**Figure 7.** Seeds of the introduced genotypes *Cicer arietinum* mobilised to the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine

**Note:** 1 – CAAFGK-1, 2 – CAAFGD-2, 3 – CAAZEMR-1, 4 – 'Tyson'5 – CAOCHL, 6 – CAUKR, 7 – CAAZEUR-2, 8 – CATADJK-1, 9 – CATADJD-2, 10 – *G. max*, 'Soniachna' (for comparison)

Assessment of the biochemical composition of plants is of great scientific and practical importance not only for determining their economic value but also for determining the level of BAC (biologically active compounds) deposited in plant seeds, which allows to establish the manifestation of their adaptive capacity to biotic and abiotic environmental factors (Rakhmetov *et al.*, 2017). Therefore, along with the biological and morphological characteristics of plants, a comprehensive study of the phytochemical characteristics of introduced *Cicer arietinum* genotypes is an urgent task.

S. Soysal & M. Erman (2020) note that *C. arietinum* genotypes in Syria can accumulate a significant proportion of absolute dry matter in seeds in the range of 93.98-95.97%, which is achieved by treating crops with *Mesorhizobium ciceri* during the period of juvenile plant development. Under NBS conditions, all genotypes were not treated with any stimulant to objectively assess the biological potential of each of them. The seeds of the introduced plant genotypes were analysed for the content of certain structural and functional (absolute dry matter), biologically active compounds (total sugar) and macronutrients (phosphorus), which potentially reflect the level of adaptation ability of a particular genotype to environmental conditions at the initial stages of its ontogeny. A high level of absolutely dry matter indicates the deposition of plastic substances for the mobilisation of all vital processes in seeds. It was found that *Cicer arietinum* plants of CAAFGD-2, CAAFGK-1, CATADJD-2 and CATADJK-1 accumulated the highest level of absolutely dry matter (from 89.04 to 89.68%), and CAAZEMR-1 – 88.28% (Fig. 8).

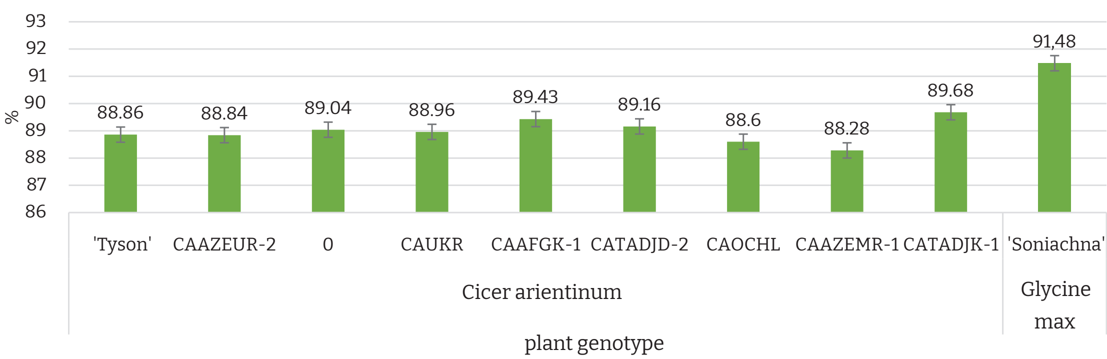


**Figure 8.** Absolute dry matter content in *Cicer arietinum* seeds depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

The accumulation of sugars is of particular importance for the frost and drought tolerance of plants, which is important when sowing plants in early spring, as crops can be stressed by the climatic rhythms of the growing area (in particular, frost or drought). High levels of sugar in cells lead to an increase in the concentration of cell sap and a decrease in water potential, which results in a lower freezing point. At the same time, sugar ensures the preservation of proteins concentrated in the cell walls, which during drought significantly slow down the evaporation of water through the cell membrane. In this way, it plays a protective role in the initial stages of plant ontogeny and ensures the stable operation of vital processes in cells (Toker *et al.*, 2021). It was found that the highest level of total sugars was characterised by samples of *C. arietinum* genotypes CATADJK-1 – 9.37%, with the average content of 'Tyson', CAAZEUR-2, CAAFGD-2, CAUKR, CAAZEMR-1 (from 5.37 to 7.67%). The lowest content of total sugars was recorded in the samples CAAFGK-1, CATADJD-2 and CAOCHL (from 3.72 to 4.01%) (Fig. 9). It is worth noting that in comparison with the results of T. Kumar *et al.* (2023), which indicate that among the 20 analysed genotypes of *C. arietinum* in India, the content of total sugars in seeds ranges from 2.84 to 4.73%, which in some cases is two times less than in the data obtained under NBS conditions.

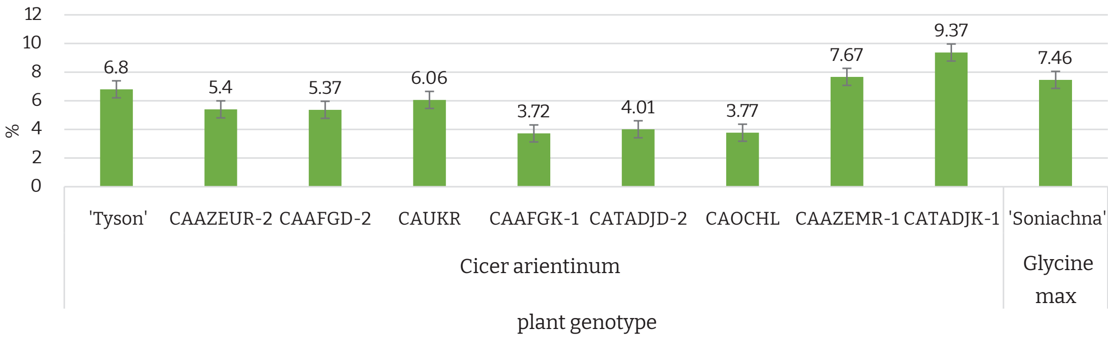


**Figure 9.** The total sugar content in *Cicer arietinum* seeds depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

Phosphorus enhances the ability of cells to retain water and increases plant resistance to frost and drought. Also, a significant phosphorus content in seeds at the initial stages of their individual growth and development contributes to the active development of the root system, namely the rapid growth of the main root and the density of root hair formation (Dida & Urga, 2018; Zaimenko *et al.*, 2022). Of the analysed genotypes, the highest amount of phosphorus was accumulated in *C. arietinum* seeds in the CAAZEUR-2 sample – 1.43%, followed by genotypes with an average level of accumulation 'Tyson', CAUKR, CATADJD-2, CAOCHL and CAAZEMR-1. CAAFGD-2, CAAFGK-1 and CATADJK-1 accumulated the least phosphorus (from 0.89 to 0.99%) (Fig. 10). The data obtained are comparable to the results of M. Tomar *et al.* (2022).

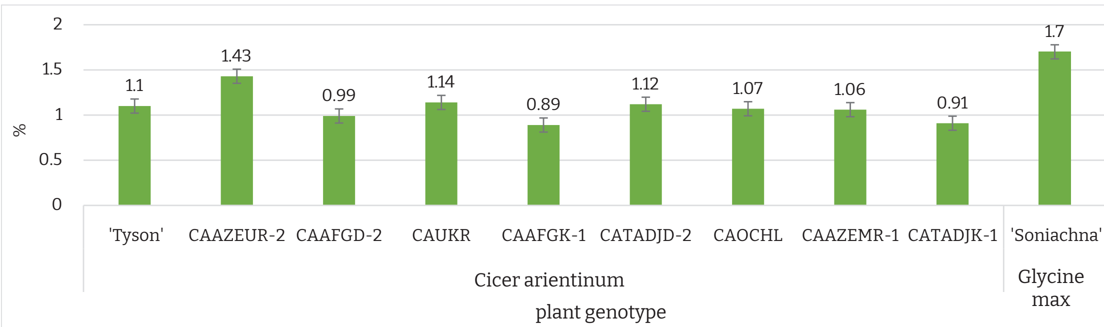


**Figure 10.** Phosphorus content in *Cicer arietinum* seeds depending on the genotypic characteristics of the source material

**Source:** compiled by the authors

Considering the obtained research results and comparing them with the literature of other authors, it should be noted that the introduced genotypes of *C. arietinum* plants have high biological potential, and several important morphophysical and biochemical features, which makes them promise for use in breeding as a valuable crop for enriching the range of legumes of domestic production.

## CONCLUSIONS

Thus, the analysis of the seed material of *Cicer arietinum* genotypes mobilised in the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine showed a significant difference between them. A significant difference in the shape and morphosculpture of the seed surface of the studied samples was found and it was revealed that these representatives belong to two morphogroups:

Kabuli (CAAFGK-1, CAAFGD-2, CAAZEMR-1, CAUKR, CAAZEUR-2, CATADJK-1, CATADJD-2) and Desi: 'Tyson', CAOCHL.

Each of the evaluated chickpea genotypes differs in size and weight of 1000 seeds depending on the region of origin. All the studied chickpea genotypes provided high parameters for biometric parameters. CAAFGK-1 prevailed in terms of linear seed size – 17.12 mm long and 14.38 mm wide. The highest weight of 1000 seeds were characterised by the genotypes of *C. arietinum* sample CATADJK-1 – 584.5 g of Tajik origin and CAAFGK-1 – 566.0 g of Afghan origin.

Among the *C. arietinum* genotypes, the CATADJK-1 sample was found to have the highest content of absolute dry matter (89.68%) and total sugars (9.37%), and the CAAZEUR-2 sample was distinguished by a high phosphorus content (1.43%). Considering these biochemical parameters may be important for the use of individual plant samples in the breeding and biotechnological process to create highly adaptive plant forms that can successfully grow in the northern regions, which will expand the cultivated area of chickpeas in Ukraine.

Thus, considering the results of research on biological, morphological, and biochemical characteristics of seeds of introduced *Cicer* genotypes, the most promising for use in breeding and biotechnological practice are samples of the Kabuli morpho-group, which provide high qualitative and quantitative indicators in Ukraine. Representatives of the Desi group are also interested as source material for creating varieties with high environmental plasticity, which in turn will allow growing plants at earlier sowing dates or completing the growing season before full maturity after autumn frosts. Therefore, further in-depth research (breeding, genetic, biotechnological, etc.) and the development of strategies for introducing new *Cicer arietinum* genotypes into production will expand the range of high-yielding legumes and improve Ukraine's food security.

## ACKNOWLEDGEMENTS

None.

## CONFLICT OF INTEREST

None.

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# Біолого-морфологічні та біохімічні особливості насіння інтродукованих генотипів рослин *Cicer arietinum* L.

**Анотація.** Актуальність дослідження обумовлена необхідністю розробки сучасних науково-практичних засад залучення до інтродукційного процесу маловідомих, малопоширених, а також новостворених генотипів рослин. Це дозволить попередити про можливу фітосировинну кризу викликану кліматичними змінами та стрімким зростанням населення на планеті. У зв'язку з цим мета досліджень полягала у визначенні морфологічних ознак та біохімічних особливостей насіння роду *Cicer arietinum* для покращення гермоплазми зернобобових культур та проведення подальших селекційних і біотехнологічних досліджень. Використано порівняльний морфологічний метод для насіння інтродукованих генотипів рослин з різних районів походження. Матеріалом для досліджень слугували 9 генотипів *Cicer arietinum*, які походять з Австралії, Афганістану, Азербайджану, України, що були вирощені на експериментальних ділянках Національний ботанічний сад імені М.М. Гришка. Вивчали морфометричні показники та окремі біохімічні властивості насіння рослин залежно від генотипових особливостей. Використовували польові, лабораторні а також методи дисперсійного аналізу і статистичної оцінки середніх даних зі застосуванням програми Microsoft Excel (2010). У ході проведених досліджень встановлено, що усі інтродуковані генотипи характеризуються високими кількісними та якісними показниками насіння. За лінійними розмірами насінин (співвідношення довжини до ширини) особливо вирізнявся зразок CAAFGK-1 – 17,12×14,38 мм, а за масою 1000 шт. насінин CATADJK-1 – 584,5 г. Біохімічні дослідження показали, що найбільше абсолютно сухої речовини накопичувалось у насінні зразків рослин *C. arietinum* – CAAFGD-2, CAAFGK-1, CATADJD-2 та CATADJK-1 (від 89,04 до 89,68 %). За рівнем загальних цукрів переважали зразки генотипів *C. arietinum* CATADJK-1 – 9,37 %, а за накопиченням фосфору домінував CAAZEUR-2 – 1,43 %. Біохімічний склад рослин дає можливість не тільки характеризувати їх цінність з точки зору продовольчої культури, але й визначити найбільш пластичні генотипи до екологічних чинників довкілля. Таким чином, отримані результати свідчать про перспективність використання окремих генотипів *C. arietinum* як вихідного матеріалу для селекційних і біотехнологічних досліджень і створення нових форм рослин, що сприятиме розширенню асортименту високопродуктивних генотипів нуту у північних регіонах України

**Ключові слова:** клімат; нут; гермоплазма; морфологічні ознаки; склад насіння