

ANNOTATION

to the dissertation work of Baitarakova Kuralay, submitted for the degree of Doctor of Philosophy (PhD) under the educational programme 8D08113 – "Plant Breeding", on the topic "Comparative study of chickpea cultivars of economically valuable characteristics in the conditions of Bogara of Almaty region"

1. Relevance of the research topic. Increasing the production of plant protein is one of the priority tasks of modern crop production and agricultural science. Protein plays a key role in ensuring human vital activity by participating in the formation of cellular structures, enzyme systems and the regulation of metabolic processes. A deficiency of protein in the diet leads to reduced immunity, impaired growth and development, as well as decreased physical and mental performance. In this regard, providing the population with complete protein is considered one of the most important factors of food security.

Under current conditions, considerable attention is paid to expanding the production of plant protein through grain legume crops, which are characterized by a high protein content and the ability to symbiotically fix atmospheric nitrogen. As noted by a number of researchers, the use of leguminous crops contributes not only to improving the level of protein nutrition, but also to enhancing the agrochemical properties of the soil, reducing the costs of mineral fertilizers and increasing the ecological sustainability of agroecosystems.

Chickpea (*Cicer arietinum* L.) occupies one of the leading positions among grain legume crops due to its high nutritional value, versatility of use and ability to form yield under limited moisture supply. According to the Food and Agriculture Organization, this crop is widely cultivated in countries with arid and semi-arid climates, where it serves as an important source of plant protein. Chickpea grain contains up to 30% protein, a significant amount of carbohydrates, vitamins and mineral substances, which determines its high food and feed value.

Modern studies show that chickpea has high adaptability to adverse environmental conditions, including drought and high temperatures. According to foreign authors such as Devasirvatham, Berger and Summerfield, the crop's tolerance is associated with physiological characteristics, including the development of the root system, efficient water use and regulation of photosynthetic activity. This makes chickpea a promising crop for cultivation under climate change and the increasing frequency of dry periods.

In Kazakhstan, chickpea is regarded as one of the promising grain legume crops for rainfed farming conditions. The expansion of sown areas and the increase in crop productivity are important tasks for the agricultural sector. Breeding work on chickpea is actively carried out in the country's leading scientific institutions, including the Kazakh Research Institute of Agriculture and Plant Growing LLP (KazNII ZiR), the A.I. Barayev Scientific and Production Centre for Grain Farming, as well as a number of experimental stations, including the Krasnovodopad Breeding Experimental Station, the Karaganda

Agricultural Experimental Station, the Karabalyk Agricultural Experimental Station and the Ural Agricultural Experimental Station.

A significant contribution to the development of chickpea breeding in Kazakhstan was made by Kudaibergenov M.S. and Baytarakova K.K., whose works substantiate the principles of selecting genotypes adapted to the conditions of the south-east of the country. According to the authors, the use of the world gene pool (ICARDA, ICRISAT) makes it possible to identify forms with high ecological plasticity, drought tolerance and stable productivity.

It has been established that the most important elements in yield formation are the weight of 1,000 seeds, the number of pods per plant and the seed weight per plant. The relationship of these traits with the level of productivity determines their significance in the breeding process and the need for a comprehensive evaluation of accessions under different agroecological conditions.

Despite the achievements made, the level of realization of the crop's potential in Kazakhstan remains insufficiently high, which is due to the influence of climatic factors and the limited range of adaptive varieties. In this regard, the study of the patterns of yield formation and grain quality in chickpea, as well as the identification of genotypes combining high productivity and tolerance to stress conditions, is of particular relevance.

Thus, conducting a comprehensive evaluation of chickpea collection material under contrasting agroecological conditions is a necessary prerequisite for increasing the efficiency of breeding work and creating new high-yielding varieties adapted to the conditions of Kazakhstan.

2. Aim of the dissertation work. The aim of the research is to conduct a comparative evaluation of chickpea accessions based on a set of economically valuable traits and to identify high-yielding, adaptive genotypes suitable for cultivation under rainfed farming conditions of Almaty Region.

3. Main objectives of the research:

1. To study a collection of chickpea accessions (*Cicer arietinum* L.) and determine the duration of the growing season of different genotypes under conditions of semi-moisture-supplied rainfed farming and irrigation in south-eastern Kazakhstan.

2. To conduct a phenotypic evaluation of chickpea accessions based on a set of economically valuable traits, including morphological indicators, yield structure elements, productivity and grain quality.

3. To carry out DNA identification of chickpea accessions in order to identify genotypes resistant to *Fusarium* rot.

4. To study the nature of intracellular physiological and biochemical changes in chickpea plants under different variants of controlled reduction of the temperature regime.

5. To develop new high-yielding chickpea varieties resistant to environmental stress factors and characterized by high grain quality indicators.

4. Research methods.

Chickpea sowing was carried out at optimal agrotechnical dates. In the dry steppe zone of Almaty Region (Karoy), sowing was performed from 21 to 30 March. At the

stationary experimental site of KazNII ZiR LLP, sowing was carried out in the first ten-day period of April (4–10 April), at a soil temperature of 8–10 °C and with a seed placement depth of 4–5 cm.

Crop care included inter-row cultivation and removal of weeds. Under the mechanized sowing method, the seeding rate was 800 thousand viable seeds per 1 ha.

Phenological observations were conducted for all variants of the experiment according to the generally accepted methodology. The onset of developmental phases was determined by counting plants and visual assessment. Observations were carried out in the first half of the day. The following developmental phases were recorded: sowing, emergence, budding, flowering, pod formation and maturity.

Structural analysis of plants was carried out according to the VIR methodology (2010). The main productivity indicators were taken into account:

- plant height, cm — stem length from the soil surface to the top of the plant;
- bush structure type: sh — spreading, k — candelabra-shaped, p — semi-compressed, s — compressed; o — limited branching; v — increased branching;
- number of productive nodes — the number of nodes bearing pods by the time of maturity;
- lodging degree, score: 1 — absent, 2 — in the upper part of the stem, 3 — from the middle part of the stem, 4 — from the base;
- weight of 1,000 seeds, g — determined at the standard moisture content of 13%;
- seed weight per plant, g.

The qualitative indicators of seeds were determined using standard methods: crude protein content according to GOST 13496.4; starch content according to GOST 10845; and amylose content according to generally accepted laboratory methods. The physical properties of grain, cooking quality and taste characteristics of pea, chickpea and lentil samples were determined in the laboratory of technological grain evaluation in accordance with GOST 6201-68, GOST 51074-97 and GOST 8756-76.

Molecular-genetic methods

Genomic DNA extraction from chickpea (*Cicer arietinum* L.) was carried out from plant seedlings using the method proposed by S. L. DeLaporta et al.

The quality of the extracted DNA was assessed by electrophoresis in a 1% agarose gel in the presence of ethidium bromide. DNA concentration was determined by the spectrophotometric method using a Jenway spectrophotometer (England).

DNA identification of collection chickpea accessions for resistance to *Fusarium* wilt was carried out by PCR using molecular markers. For the H1 locus of the FOC-1 gene, CS 27 and UBC-170 markers were used; for the FOC-2 gene, NZA12, TA37 and TA110 markers were used; for the FOC-3 gene, TA96 (STMS) and TA194 markers were used; and for the FOC-5 gene, the TA27 (STMS) marker was used. Primer synthesis was carried out by Biolabmix LLC (Novosibirsk, Russia).

Separation of amplification products was performed in 1.2% agarose and 8.0% polyacrylamide gels (Merck, Germany) stained with ethidium bromide. Visualization of amplification products and determination of PCR fragment sizes were carried out using

the Quantum ST4 gel documentation system (France). The Step50 plus DNA marker (Biolabmix LLC, Russia) was used as a molecular weight marker.

Phytopathological assessment of resistance to Fusarium wilt was conducted under field conditions according to the methodology of A. Trapero-Casa and R. M. Jimenez-Diaz. The degree of infection was assessed on a scale from 0 to 4 depending on the percentage of affected leaf surface: 0 — 0%, 1 — 1–33%, 2 — 34–66%, 3 — 67–100%, 4 — completely dead plant.

To assess the physiological state of plants, the NDVI (Normalized Difference Vegetation Index) was used, reflecting the level of photosynthetic activity. Measurements were carried out using a GreenSeeker Handheld device. Diagnostics were performed at the budding and seed filling stages during the daytime (from 11:00 to 13:00) on a fixed area.

Statistical processing of the experimental data was carried out using Microsoft Excel software. Correlation and cluster analyses were performed in the AGROS programme (modified by S. P. Martynov). The arithmetic mean, standard error and coefficient of variation were calculated according to the methodology of B. A. Dospekhov.

5. Main provisions submitted for defence:

1. The features of the formation of economically valuable traits of chickpea under conditions of semi-moisture-supplied rainfed farming and the dry steppe zone of Karoy.
2. The results of phenotypic evaluation of chickpea accessions and the identification of high-yielding and adaptive genotypes.
3. Identification of chickpea genotypes resistant to Fusarium rot using DNA markers.
4. Physiological and biochemical mechanisms of chickpea adaptation to low temperatures.
5. Development and transfer to production of new patented chickpea varieties "Miras 07", "Nurly 80", "Satti", "Er-Sultan", "Samga", "Alpamys" and "Akzhol", obtained as a result of the conducted breeding work.

6. Substantiation of the novelty and significance of the obtained results.

Promising chickpea accessions have been identified that can be used in breeding as donors of high yield and resistance to drought, low temperatures and Fusarium rot.

The developed approaches to the comprehensive evaluation of economically valuable, physiological-biochemical and molecular-genetic traits make it possible to increase the efficiency of selecting initial breeding material and to accelerate the development of adaptive chickpea varieties.

As a result of the conducted research, new high-yielding chickpea varieties — "Miras 07", "Nurly 80", "Satti", "Er-Sultan", "Samga", "Alpamys", "Akzhol", "Derkul" and "Aknar" — were developed and adapted to different soil and climatic conditions of Kazakhstan. The varieties were submitted for State Variety Testing and recommended for cultivation in various agroecological zones of the republic.

7. Compliance with the directions of scientific development or state programmes.

The dissertation work was carried out in the Department of Grain Legume Crops of the Kazakh Research Institute of Agriculture and Plant Growing LLP within the framework of state programmes and scientific projects of the Ministry of Agriculture and the Ministry of Science and Higher Education of the Republic of Kazakhstan. The studies were conducted within the framework of the following research programmes and projects: 2021–2023 — BP 267 "Development of high-yielding varieties and hybrids of grain legume crops based on advances in biotechnology, genetics, physiology and biochemistry of plants for their sustainable production in various soil and climatic zones of Kazakhstan" (state registration No. 0121RK00772); 2024–2026 — project BR22885414 "Development of high-yielding varieties of grain legume crops based on methods of modern biology, development of their varietal technology and primary seed production".

8. Description of the doctoral candidate's contribution to the preparation of each publication.

The results of the dissertation research were repeatedly discussed and reported at meetings of the Academic Council of the Kazakh Research Institute of Agriculture and Plant Growing, as well as during the implementation of scientific programmes and projects (2022–2025).

The main scientific results and conclusions of the dissertation were presented at the following international scientific and practical conferences and discussed by the scientific community:

- "Adaptation of Crop Production to Global Climate Change: Problems and Solutions" (Kazakhstan, Almaty Region, Almalybak settlement, 24–25 June 2022);
- "Seifullin Readings – 18: Youth and Science — a Look into the Future" (Kazakhstan, Astana, 2022);
- "History and Modernity: Agricultural Research in the Field of Farming and Plant Growing" (Kazakhstan, Almaty Region, Almalybak settlement, 2024);
- "Breeding, Genetics and Agrotechnology of Agricultural Crop Cultivation: Achievements and Prospects for Development" (Kazakhstan, Almaty Region, Almalybak settlement, 19–20 June 2025).

Approbation of the work.

The main results of the dissertation research were presented and discussed at international and republican scientific conferences and round tables, including the round table "History and Modernity: Agricultural Research in the Field of Farming and Plant Growing", dedicated to the 90th anniversary of the Kazakh Research Institute of Agriculture and Plant Growing (Almalybak, 2024).

Structure and scope of the dissertation work.

The dissertation is presented on 176 pages and consists of an introduction, 6 sections, a conclusion and recommendations for production. The dissertation contains 18 tables, 45 figures and 8 appendices. The list of references includes 281 sources.