RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
58 (2) 604-614, 2026
http://doi.org/10.54910/sabrao2026.58.2.11
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

DEVELOPING ENVIRONMENTALLY ADAPTED AND HIGH-YIELDING CHICKPEA (*CICER ARIETINUM* L.) CULTIVARS IN WEST KAZAKHSTAN

G.KH. SHEKTYBAEVA*, **V.B. LIMANSKAYA, A.S. KASENOVA,**
M.S. KUDAIBERGENOV, and K.ZH. BAITARAKOVA

Ural Agricultural Experimental Station, Kazakh Research Institute of Agriculture and Plant Growing, Almaty Region, Kazakhstan
*Corresponding author's email: gkhshektybayeva@mymail.academy
Email addresses of co-authors: limanskaya@mymail.academy, askasenova@mymail.academy,
m.s.kudaybergenov@mymail.academy, kzhbaytarakova@mymail.academy

SUMMARY

The study aimed to assess and identify high-yielding chickpea (*Cicer arietinum* L.) cultivars resistant to abiotic stresses and adapted to the arid conditions of West Kazakhstan. With moisture deficit conditions, frosts, high temperatures, and low soil fertility, it was crucial to select the genotypes with high ecological plasticity and stable productivity. The experimental studies, carried out during 2021–2024 at the Ural Agricultural Experimental Station, Kazakhstan, used the methodology of ecological variety testing. The following research involved a comprehensive evaluation of 50 chickpea genotypes based on yield-related traits, drought resistance, and disease resistance. The results highlighted that the chickpea cultivars Akzhol, Privo 1, G' 97-121, G' 97-60, and F 97-50 exceeded the standard cultivar Jubilee in yield by 0.21–0.25 t/ha. The study also recommended the cultivar Akzhol for state cultivar testing. The results authenticated the selection of promising chickpea genotypes under the arid and environmental conditions of West Kazakhstan.

Keywords: Chickpea (*C. arietinum* L.), adaptation, drought, grain yield, selection, economically valuable traits, West Kazakhstan

Key findings: The four-year ecological cultivar testing (2021–2024) under arid conditions in West Kazakhstan identified the five chickpea (*C. arietinum* L.) cultivars Akzhol, Privo 1, G' 97-121, G' 97-60, and F 97-50 that consistently outperformed the standard cultivar Jubilee by 0.21–0.25 t/ha in yield. The Akzhol cultivar also showed the highest ecological adaptability and productivity and was submitted for state cultivar testing.

Communicating Editor: Prof. Dr. Zahoor Ahmed Soomro

Manuscript received: August 2, 2025; Accepted: February 19, 2026.

Citation: Shektybaeva GKh, Limanskaya VB, Kasenova AS, Kudaibergenov MS, Baitarakova KZh (2026). Developing environmentally adapted and high-yielding chickpea (*Cicer arietinum* L.) cultivars in West Kazakhstan. *SABRAO J. Breed. Genet. 58 (2) 604-614. http://doi.org/10.54910/sabrao2026.58.2.11*.

INTRODUCTION

In the face of exacerbating moisture deficit, growing air temperature, and diminishing soil fertility conditions, research devoted to developing resistant crop cultivars gains particular relevance. Chickpea (*Cicer arietinum* L.) is the promising crop for arid regions, a source of high-quality plant protein and biological nitrogen fixation. However, the extreme variations in agroclimatic conditions of West Kazakhstan call for the development of chickpea cultivars with high adaptability and productivity. Therefore, this necessitates a comprehensive study of chickpea germplasm under field conditions to identify the most productive and resilient genotypes capable of ensuring stable yield under climate stress conditions (Sagan and Iskakov, 2014).

The contrasting soil and climatic conditions of West Kazakhstan and its low bioclimatic potential drive the constant search for chickpea cultivars with the highest ecological plasticity. In a successful resolution of the said issue, the primary role belongs to the scientifically grounded selection of chickpea cultivars (Checherina, 2013). The research's main aim deals with the study and development of new chickpea cultivars, resistant to environmental stress conditions, as characterized by high productivity and good grain quality for cultivation in the arid conditions of West Kazakhstan. The West Kazakhstan Region drastically differed by soil and climatic conditions from other regions of the country. In such challenging environmental conditions, the crop cultivars that can fully address an all-encompassing negative influence of limiting environmental factors, which are highly specific to the particular zoning area, become crucial (Berdagulov *et al*., 2009; Rozhanskaia and Kurkova, 2014; Shektybaeva *et al*., 2021).

Chickpea is the leading grain legume crop and an excellent source of plant protein. The chickpea's value lies in its ability to improve soil fertility by enriching it with atmospheric nitrogen. Given the symbiosis with specific bacteria, chickpeas assimilate atmospheric nitrogen and synthesize physiologically active compounds while their root secretions have the highest acidity, which further promotes the dissolution of phosphates (Germantseva *et al*., 2009; Gummatov, 2017; Rzaeva and Lakhtina, 2018). The chickpea crop is not very demanding in terms of the preceding crop. Chickpea sowing can be successful after corn, rapeseed, buckwheat, and other crops. Generally, sowing chickpeas should not continue after leguminous grasses and grain legumes.

Chickpeas can survive under moisture deficit conditions and allow farmers to obtain stable yields even in changing climate conditions as compared with other crops. Chickpea growing can proceed on almost all types of soils; for soil preparation in spring, the one harrowing and pre-sowing tillage proved sufficient for getting optimum grain yield. It is because chickpeas are resistant not only to drought but also resilient to returning frosts (up to -12 °C) and can be sown early (Guz and Aituev, 2004; Chekalin and Limanskaia, 2009; Namazbekova *et al*., 2022).

High-quality seed is the foundation of better future crops for good sowing qualities and has the highest yield potential. Determining the seed value could be whether it carries the complete genetic information of the genotypes, as well as the biological properties, incurring influences from hereditary factors and existing environmental conditions (Kashevarov and Bodiagin, 2010; Medvedev and Utuchenkov, 2010). Nevertheless, the newly improved cultivars play a primary role in increasing grain yield stability. West Kazakhstan houses two chickpea cultivars: Jubilee—developed by the Krasnokutsk Breeding and Experimental Station (1967 zoning), and Volgogradsky 10—selected by the Volgograd State Agricultural Academy (1990 zoning).

The State Register of Selective Breeding Achievements Permitted for Use in Kazakhstan, dated May 04, 2024, specifies a total of 12 chickpea cultivars. These include six cultivars selected in Kazakhstan (Zhanalyk, Ikarda 1, Kamila 1255, Karabalyksky 1, Nurly 80, and Symbat 1), five cultivars developed in Russia (Volgogradsky 10, Krasnokutsky 123,

Table 1. Agro-climatic zoning of key agricultural crops.

No.	Regions	Cereals	Leguminous crops	Oleaginous and industrial crops	Vegetable crops
1	Bayterek District Uralsk City Borili District Shyngyrlau District (North, center) Terekti District (North) Taskala District (North, center) Syrym District (Northern outskirts) Zhanybek District (northern outskirts)	Wheat (s, h) Winter wheat Winter rye Rye Oats Panicgrass Buckwheat Corn-e Sorghum-ne	Beans Peas Lentils Lathyrus Chickpea Legumes Lupin Soybean-ne Soybean-e	Flax Sunflower Rapeseed Sugar beet-e Sugar beet-m	Potatoes Cabbage Cucumbers Tomatoes
2	Shyngyrlau District (South) Terekti District (South) Taskala District (South) Syrym District (Center, South) Zhanybek District (Center, South) Kaztal District (North, Center) Akzhaik District (North) Karatobe District (North, center)	Wheat (s) Winter wheat Winter rye Rye Oats Panicgrass Buckwheat Corn-e Corn-m Sorghum-e	Beans Peas Lentils Lathyrus Chickpea Legumes Lupin Soybean-ne Soybean-e Soybean-m	Flax Sunflower Rapeseed Sugar beet	Potatoes Cabbage Cucumbers Tomatoes
3	Kaztal District (South) Akzhaik District (South) Karatobe District (South) Bokey Orda District Zhanakala District	The moisture conditions are insufficient for the cultivation of agricultural crops.			

Rovensky, Sokol, and Jubilee), and one cultivar from Germany (Lider) (Skokbaev, 2002; Dospekhov, 2012; Kiseleva and Rzaeva, 2019).

Chickpea is a traditionally viewed insurance crop in the agricultural system of West Kazakhstan. In this connection, an urgent task is vital to identify and select new cultivars with increased yield and a combination of economically valuable traits, adapted to the specific soil and climatic conditions of this region (Germantseva *et al*., 2009; Bushulian and Sichkar, 2011; Demchenko, 2011). Solving this issue requires in-depth and comprehensive scientific research on the chickpea germplasm (Kuptsov and Boris, 2008; Balashov *et al*., 2010; Elunin, 2014).

The main goal of the study is to systematically examine chickpea breeding material, identify the sources of valuable traits and properties based on ecological selection, and create new competitive and patentable varieties adapted to the agroecological conditions of the region (Germantseva *et al*., 2009; Bushulian and Sichkar, 2011; Demchenko, 2011).

MATERIALS AND METHODS

Study area and experimental design

Based on the analysis of local agroclimatic conditions, the division of the West Kazakhstan region succeeded into four suitable zones for the cultivation of key agricultural crops (Table 1). The series of studies on chickpeas ensued during 2021–2024 at the Ural Agricultural Experimental Station, West Kazakhstan (51°13′N, 51°23′E). The research involved ecological cultivar testing of chickpea (*C.*

arietinum L.) cultivars developed by the five different research institutes. These are the Kazakh Research Institute of Agriculture and Plant Growing, the Krasnokutsk Breeding and Experimental Station, Volgograd State Agricultural Academy, the Krasnovodopad Agricultural Experimental Station, and the A.I. Barayev Research and Production Centre for Grain Farming, Kazakhstan. These chickpea cultivars reached evaluation at the nursery based on the main economically valuable traits.

Soil and climatic conditions

The layout of experiments was on non-irrigated, dark chestnut, and heavy loamy soils with a humus content of 2.7%. The moisture content is the main hindrance in increasing the chickpea crop yield in this region. The weather conditions during the study period of 2021–2024 mostly fully reflected the characteristics of West Kazakhstan's continental climate. In 2021, the early growing season markedly had above-normal temperatures. May exceeded the norm by 34% (21 °C vs. 16 °C) and June by 17% (24.5 °C vs. 20.9 °C). Heavy rains were abundant at the end of May (89 mm over six days), easing stress during seedling emergence. However, June brought a 25-day drought with daytime air temperatures of 33.5 °C–41.8 °C and soil heating (50 °C–55 °C), with no rainfall. From June 15–30, daily average temperatures reached 28.8 °C–31.9 °C, far above the long-term norm of 20.9 °C. Therefore, the chickpea plants' growth occurred under extreme atmospheric and soil drought, although initial soil moisture (110 mm at sowing) and rising temperature at the end of May ensured uniform and early germination.

In 2022, chickpea growth and development incurred constraints from heat and drought. July averaged 25.1 °C (norm at 22.9 °C) with 17 mm of rain (norm at 40 mm), and August was 26.0 °C (norm at 21.1 °C) with no rainfall (norm at 27 mm). Earlier, April was warmer (+3.5 °C) with normal precipitation, while May was cooler (–3.6 °C) but emerged wetter. Severe drought in June (8 mm vs. 33 mm) and July depleted the soil moisture, and from late July through August, no rainfall occurred. Thus, plant growth proceeded under prolonged atmospheric and soil drought, with only September rainfalls (30.9 mm vs. 29 mm).

Spring 2023 was early, with soils drying by April 10. April had a slight precipitation deficit and a +2.8 °C heat surplus, while early May was wetter (+3.7 mm) and warmer (+2.9 °C). From late May to early June, a heatwave pushed temperatures to 30.6 °C–33.2 °C, followed by hot winds and mid-June peaks up to 36 °C. June saw a precipitation deficit of 26.3 mm and an extremely low hydrothermal coefficient (HTC) of 0.1. By late June–early July, temperatures rose to 31 °C–41 °C. Heavy rains in mid-July (152 mm vs. 40 mm norm) raised the HTC to 2.1, the highest since 1992. These rains cooled August to 19 °C–25 °C, though HTC again fell to 0.

The 2023–2024 crop season began with a warm and wet October. The average monthly temperature increased by 1.2 °C, coupled with a precipitation surplus of 15.5 mm (54.5 mm compared to the norm of 39 mm). November was also 4.7 °C warmer than the long-term average, with abundant productive precipitation of 45.9 mm (norm of 28 mm), which considerably replenished the soil moisture reserves before the onset of winter.

Winter conditions were unstable: December was warmer than normal (+3.2 °C) with excess precipitation, mainly as rain; January was colder than normal (−2.0 °C); and February was close to average. Precipitation in January and February slightly exceeded norms and also fell mostly as rain, resulting in low snowfall, frequent thaws, sharp temperature fluctuations, and the formation of a snow crust. Spring 2024 began early, with the transition above 0 °C occurring on March 23–24, followed by rapid warming (5 °C on March 29 and 10 °C on April 1). March temperatures were near average with higher-than-normal precipitation, while April was exceptionally warm (+6.8 °C above normal) and dry, with daytime temperatures reaching 25 °C–29 °C.

May showed characteristics of strong temperature variability (5.1 °C–20.1 °C), an overall heat deficit, and recurrent frosts down to −3 °C in early May that damaged seedlings of early crops. By late May, a moisture deficit developed due to precipitation of 18 mm below normal. Late May and June experienced intense heat (29 °C–37 °C), partially mitigated by rainfall events in early and late June. July and August temperatures were near long-term averages, with precipitation concentrated mainly in mid–late July and early August. From mid-August through September, no precipitation appeared, and in September, the HTC amounted to 0.

Traits measurement and analysis

The recording of main morphometric and agronomic traits of chickpea plants happened at full maturity. Observations included the duration of the growing period, plant height, stem height to the lower leaf layer, height of the lowest pod attachment, the number of pods per plant, and 1000-grain weight. Grain yield, as determined from the central plot area, underwent conversion to tons per hectare at a standard grain moisture of 14%. Biochemical indicators, such as feed units and digestible protein content, sustained analysis according to conventional methods used in legume breeding research.

Statistical analysis of the obtained data proceeded using the analysis of variance (ANOVA) method described by Dospekhov (2012), with the least significant difference ($LSD_{0.05}$) calculated to assess the reliability of differences among cultivars. Mean values and standard deviations entailed computations for each trait. Determining correlations between yield and related traits sought to evaluate their contribution to productivity following approaches outlined by Paul *et al*. (2022) and Jain *et al*. (2022).

RESULTS AND DISCUSSION

In the ecological nursery based on four-year (2021–2024) phenological observations, the studied chickpea (*Cicer arietinum* L.) cultivars demonstrated early maturity with a growing period of 79–85 days under arid conditions. On average, the period from germination to flowering was 35 days (Table 2). The crop maturity time closely aligns with similar past studies of Sachdeva *et al*. (2022), who recorded the same average maturity time in studying the agronomic performance of chickpeas under drought stress conditions. The latest results were also greatly analogous to the findings of Gurumurthy *et al*. (2022), who classified a 100-day growing period as a sign of early maturity in chickpeas under water-deficit environments. These previous studies further reinforced that early-maturing chickpea genotypes boost their productivity in short seasons, decrease losses from terminal drought and heat stress, and enhance crop rotation flexibility, which eventually increases grain yield and improves food security.

Over four years of study and at the time of physiological maturity, the average plant height was 45.1 cm in chickpea genotypes (Table 2). However, the variation for plant height among the cultivars ranged from 40.9 to 49.2 cm. The chickpea genotypes with the high attachment of the lowest pod and a compact bush shape had the most value. In the studied cultivars, the lowest pod height ranged from 19.1 to 21.2 cm. Based on this parameter, the best-performing cultivars and lines were Karabalyksky 1 (21.2 cm), F 97-50 (21.1 cm), F 92-52 (20.5 cm), and Privo (20.2 cm). In these four chickpea genotypes, the average height of the lowest pod amounted to 19.1–21.2 cm. In the standard cultivar, the average bottom pod height was 19.2 cm. Although this trait is not a component of productivity per se, it can have a direct impact on grain yield. These results align with past studies of Paul *et al*. (2022) and Jain *et al*. (2022), who agreed in their study that plant height may have a direct correlation with grain yield in chickpea genotypes.

High-quality mechanized harvesting of the chickpea largely depends on the lowest pod attachment height, as determined by the biological features of cultivars and environmental conditions. In West Kazakhstan, high-yielding cultivars can be both short and tall. However, a strong preference for the latter

Table 2. Characteristics of the outstanding chickpea cultivars in the ecological nursery (average over 2021–2024).

Cultivars	Growing season (days)	Plant height (cm)	Stem height to lower leaf layer (cm)	Bottom pod attachment height (cm)
Jubilee (Standard)	79	40.9	10.9	19.2
Privo 1	79	47.1	11.7	20.2
G' 02-10 (Akzhol)	81	45.5	12.4	19.9
G' 97-121	83	48.7	11.7	19.5
G' 97-60	79	49.2	11.8	20.2
F97-50	82	41.2	12.5	21.1
Karabalyksky 1	79	43.4	10.9	21.2
F 98-30	80	43.5	10.7	19.1
13-B	82	43.8	10.8	20.2
F 92-52	84	45.5	12.5	20.5
TN 45/01	85	48.8	11.2	19.3
F 99-55	82	43.8	10.8	20.2
Er-Sultan	79	42.9	10.9	19.1
ZK-8	81	43.1	10.7	20.2
Bonus	83	42.4	10.8	20.5

was due to their greater adaptability to the region's unfavorable abiotic and biotic factors. Jain *et al*. (2022) proposed that taller chickpea genotypes typically have more branches, pods, and biomass, which potentially contribute to higher seed yield. However, their findings stated plant height is one of the yield-contributing variables, and its direct effect is frequently less substantial than other traits, such as the pods per plant. Paul *et al*. (2022) also concluded days to flower initiation showed the highest direct effect on seed yield.

Across the four years, all chickpea genotypes demonstrated resistance to pests and diseases. In West Kazakhstan, chickpeas remain virtually undamaged by the pea leaf miner, the pea weevil, and the pea moth. However, during the crop seasons of 2022 and 2023, chickpea genotypes experienced minor damage from plurivorous pests, such as the cotton bollworm and occasional gnawing pests. With high temperature and low atmospheric humidity, plant diseases (Ascochitosis and rust) were not evident. The pest and disease resistance displayed by the chickpea genotypes suggested the presence of molecular markers that trigger disease resistance. However, for more accurate results, comprehensive molecular analysis is crucial to identify these markers. Likewise, it will assess the resistance to common legume diseases like Fusarium wilt, Ascochyta blight, Botrytis gray mold, dry root rot, collar rot, sclerotinia stem rot, rust, stunt disease, and phyllody in chickpea genotypes (Choudhary *et al*., 2022; Kaur *et al*., 2023).

Over four years of study, the grain yield of the standard cultivar Jubilee amounted to 1.01 t/ha with a harvest humidity of 14%. A significantly higher grain yield resulted in 14 chickpea cultivars. Several cultivars excelled the standard cultivar by 0.10–0.25 t/ha, i.e., Privo 1, G' 02-10 (Akzhol), G' 97-121, G' 97-60, and F 97-50 (Table 3 and Figure 1). The 1000-grain weight is one of the most important yield-related traits. In the grain market, most preference centers on the large-seeded chickpea cultivars with an absolute 1000-seed mass averaging at 244.7 g. All the studied chickpea cultivars distinguished by grain yield had a fairly high indicator of the 1000-grain weight, as observed in cultivars G' 02-10 – Akzhol (285.5 g), F 96-60 (278.3 g), and F 97-121 (277.0 g). Takele *et al*. (2022) also concluded that the average 100- and 1000-grain weight is a very valuable trait in chickpeas and other grain crops. The studies suggested a greater average 1000-grain weight results in a greater grain yield. The studies further proposed that although larger and possibly better-filled grains, as indicated by a higher 1000-grain weight, the final grain yield incurs influences from other factors, such

Table 3. Productivity of the best chickpea cultivars in the ecological nursery during 2021 to 2024.

Cultivars	Grain yield (t/ha)				Means	Deviation from the standard
	2021	2022	2023	2024		
Jubilee (Standard)	1.32	0.91	1.09	0.71	1.01	–
Privo 1	1.75	1.09	1.37	0.84	1.26	0.25
G' 02-10 (Akzhol)	1.71	1.16	1.35	0.80	1.26	0.25
G' 97-121	1.72	1.12	1.32	0.82	1.25	0.24
G' 97-60	1.71	1.14	1.29	0.81	1.24	0.23
F97-50	1.69	1.10	1.30	0.80	1.22	0.21
Karabalyksky 1	1.50	1.10	1.25	0.80	1.18	0.17
F 98-30	1.67	1.04	1.24	0.77	1.18	0.17
13-B	1.64	0.99	1.23	0.76	1.16	0.15
F 92-52	1.51	1.05	1.24	0.80	1.15	0.14
TN 45/01	1.62	1.03	1.20	0.75	1.15	0.14
F 99-55	1.49	1.04	1.23	0.79	1.14	0.13
Er-Sultan	1.57	1.0	1.18	0.81	1.14	0.13
ZK-8	1.60	0.97	1.21	0.72	1.13	0.12
Bonus	1.44	1.03	1.21	0.76	1.11	0.10
$LSD_{0.05}$	0.13	0.11	0.12	0.07	0.11	

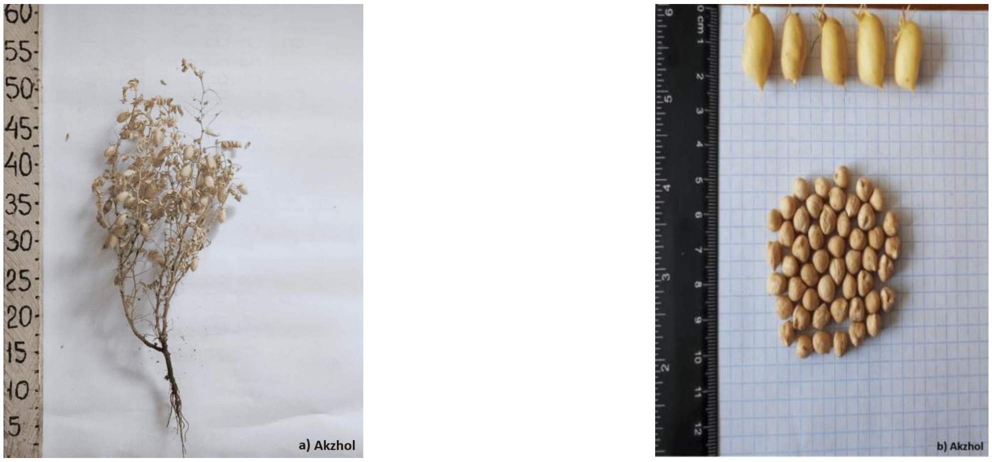

Figure 1. Chickpea cultivar Akzhol: a) complete plant, and b) pods and grains.

as the grains per plant and the existing environmental conditions.

From four years of study (2021–2024), the assessment identified the high-yielding chickpea genotypes that received distinction by their grain yield, growing period, oil content in seeds, and many other economically valuable traits. For grain yield, the best-performing chickpea cultivars and lines were Privo 1 (1.26 t/ha), G' 02-10 – Akzhol (1.26 t/ha), G' 97-121 (1.25 t/ha), G' 97-60 (1.24 t/ha), and F 97-50 (1.22 t/ha) (Table 4). Demonstrating high grain yield compared to existing standards, the selected cultivars prove promising for further use in the selection process through breeding. These results provide a sound genetic basis for developing new cultivars with improved, economically valuable traits. The application of such cultivars in selection considerably enhances the efficiency of agriculture, allowing high yields and adapting genotypes to extreme environmental conditions, such as droughts and low temperatures. The presented study identified the promising chickpea genotypes with optimum growing season, higher yields, grain protein content, and other economically valuable traits. Studies in different geographical areas revealed chickpea's

Table 4. Grain yield and its components of chickpea cultivars in the ecological nursery (average over 2021–2024).

Cultivars	Grain yield (t/ha)	Percent increase over standard	1000-grain weight (g)	Pods plant^{-1}	Harvest index (%)
Jubilee (Standard)	1.01	100.0	244.7	68.5	48.0
Privo 1	1.26	134.1	262.1	78.1	48.9
G' 02-10 (Akzhol)	1.26	131.8	285.5	69.4	57.3
G' 97-121	1.25	130.3	277.0	78.4	51.8
G' 97-60	1.24	128.7	278.3	77.3	62.7
F97-50	1.22	128.0	257.5	61.4	50.6
Karabalyksky 1	1.18	127.2	254.6	71.6	67.9
F 98-30	1.18	122.7	259.9	61.2	77.0
13-B	1.16	121.2	260.4	56.2	43.7
F 92-52	1.15	121.2	255.2	59.8	52.3
TN 45/01	1.15	120.4	223.4	61.6	46.9
F 99-55	1.14	119.6	252.4	69.4	57.3
Er-Sultan	1.14	118.1	264.2	78.4	51.8
ZK-8	1.13	118.1	258.0	77.3	62.7
Bonus	1.11	117.4	254.6	61.4	50.6
LSD$_{0.05}$	0.11				

Table 5. Characteristics of the main biochemical traits in chickpea grains (average over 2021–2024).

Cultivars	Feed units	Digestible protein (g/kg)
Jubilee, standard	1.27	23.0
Privo 1	1.32	24.2
Er-Sultan	1.30	23.0
Akzhol	1.32	24.2
Derkul	1.30	22.8

cultivation can succeed even with higher humidity. The low harvest humidity may be a causative effect of the chickpea's resistance to diseases (Khaliq *et al*., 2022). In chickpea genotypes, the infection and disease development are favorable with temperatures ranging between 10 °C and 30 °C and a relative humidity over 95% (Korbu *et al*., 2022).

According to the Krasnokutsk Breeding and Experimental Station (Checherina, 2013), in digestible protein, chickpeas considerably excelled barley, which is the leading grain and forage crop in this zone. The 100 kg of chickpea grains contain 19.5 kg of digestible protein, while barley has only 8.5 kg. Furthermore, chickpea's protein displays a high content of essential amino acids, primarily lysine, and its content reaches 31.8 g/kg. For feed units, four chickpea cultivars were the most productive. The standard and other four cultivars identified through selection had a feed unit content of 1.27 (Table 5). The content of digestible protein in the grain of the standard Jubilee cultivar was 23 g/kg, and the cultivars Privo 1 and Akzhol also showed higher levels. These values align with recent findings that chickpea seed protein content exhibits considerable genotypic variation and may trade off with yield in stress conditions (Jha *et al*., 2024). Moreover, structural aspects of chickpea proteins, such as globulin/albumin composition and processing impacts (e.g., heat, fermentation), strongly influence digestibility, which underlines the significance of evaluating both quantity and quality of protein in cultivars (Liu *et al*., 2023).

Based on the presented comprehensive study using ecological cultivar testing, cultivar Akzhol (G' 02-10) succeeded in its submission for state cultivar testing in 2023. This said chickpea cultivar reached its development at the Ural Agricultural Experimental Station as a result of individual selection from the introduced hybrid population of Akzhol (G' 02-10). The said genotype has a plant height of 50–58 cm, with a straight-tipped stem, an upright bush, and 5–8 branches per plant. The flower is solitary, the peduncle is short, and the flower color is white. At maturity, the pod is light-colored, measuring 2.5 cm x 1.5 cm, with two seeds per pod and a 1000-grain weight of 290–310 g. The seed is round and white, with a slightly wrinkled and matte white surface. The cultivar Akzhol is almost resistant to ascochitosis. The lowest pod height was 20–25 cm, with bushy plants and an upright shape, found suitable for mechanized harvesting. On average, the growing season lasts 80–84 days. The cultivar Akzhol's average grain yield over 2021–2023 was 1.39 t/ha, which was 0.28 t/ha higher than the standard cultivar. The said chickpea cultivar is considerably better for food products, with a recommendation for cultivation in West Kazakhstan. This yield advantage demonstrates the cultivar's high adaptive potential under arid conditions, where temperature fluctuations and soil moisture deficits often limit productivity. A report of similar outcomes came from Tiwari *et al*. (2023), who identified drought-tolerant chickpea genotypes maintaining superior yield stability and seed quality across water-limited environments.

The promising study successfully identified several high-yielding chickpea cultivars adapted to the arid conditions of West Kazakhstan, although with limitations. Meanwhile, the four-year study at the single experimental station may not adequately represent the cultivars' long-term stability and performance in the wider region's varied soil types and microclimates. A more thorough evaluation involving artificial inoculation and molecular screening for resistance genes is essential to validate these results, as the disease resistance was evident under a low disease pressure condition. Therefore, a more robust assessment involving artificial inoculation and molecular screening for resistance genes is necessary to confirm the resistant traits. Future studies should combine field trials with molecular assays to confirm the stability of resistance and identify potential resistance alleles linked to major pathogens, such as *Ascochyta rabiei* and *Fusarium oxysporum*. Recent findings by Choudhary *et al*. (2022) emphasized that integrating conventional and molecular breeding approaches greatly enhances the precision of selecting chickpea genotypes with durable, multi-pathogen resistance.

Furthermore, this relevant study concentrated on morphological and agronomic characteristics, which allowed for a more thorough examination of the physiological processes that underlie the observed drought tolerance, such as root architecture and water-use efficiency. Therefore, to confirm disease resistance genes, molecular marker-assisted selection requires application in future research to validate yield stability, prioritize multi-location trials over a long period, and explore the physiological underpinnings of abiotic stress adaptation. Such integrated approaches will be crucial for developing resilient chickpea cultivars that can ensure sustainable productivity in the face of climate change. In conclusion, the chickpea cultivars Akzhol, Privo 1, G' 97-121, G' 97-60, and F 97-50 revealed significant promise for improving chickpea production in arid regions, and their integration into breeding programs represents a positive step toward enhancing food security in West Kazakhstan. Recent work shows that combining physiological screening with modern genomics/multi-omics accelerates the identification of drought-resilient chickpea lines and clarifies underlying mechanisms, supporting this strategy for breeding programs (Kudapa *et al*., 2024).

CONCLUSIONS

Based on four years' study, four chickpea (*C. arietinum* L.) cultivars Privo 1, G' 97-121, G' 97-60, and G' 02-10 emerged for selection. These cultivars proved resistant to lodging and shattering, with uniform maturity. With a lowest pod height of 20.2 cm, these genotypes appeared well suited to mechanized harvesting. These promising chickpea genotypes were also early-maturing, with higher productivity and enhanced protein content. Ecological evaluation confirmed the genotypes' values, and the ongoing trials aim to identify the most adapted chickpea cultivars for breeding in West Kazakhstan. The study took place at a single site on one apple cultivar, which may limit the applicability of the results to other regions and varieties. Additionally, the three-year duration does not capture long-term climatic variability or economic performance of the irrigation systems.

ACKNOWLEDGMENTS

The conducted research was in the framework of a program-targeted funding by the Ministry of Agriculture of the Republic of Kazakhstan under budget program BR22885414, "Creation of highly productive cultivars of grain legumes based on the methods of modern biology, the development of their varietal technology, and primary seed production."

REFERENCES

Balashov VV, Balashov AV, Kulikova NA, Khabarov AM (2010). Features of the technology for cultivating chickpea varieties developed in Volgograd. In: Proceedings of the International scientific and practical conference 'Nauchnoe obespechenie razvitiia agropromyshlennogo kompleksa stran tamozhennogo soiuza', Vol. III. AO KazAgroInnovatsiya, Astana, pp. 147–152.

Berdagulov MA, Iskakov KI, Chudinov VA, Shilo EV (2009). Scientific support for producing competitive agricultural products: Collection of scientific papers dedicated to the 80th anniversary of the founding of the Karabalyk Agricultural Society. Karabalykskaya SKHOS, Nnauchnyy, pp. 133–137.

Bushulian O, Sichkar V (2011). Chickpeas as the new trump card of crop rotation. *Zemledelie* 7: 156–158.

Checherina AN (2013). Evaluation of the lentil subspecies specimens for high growth and productivity in the conditions of North Kazakhstan. *Vestnik selsko khoziaistvennoi nauki Kazakhstana* 2: 20–23.

Chekalin SG, Limanskaia VB (2009). Agricultural resource potential of chickpea in West Kazakhstan. In: No-till and crop rotation are the basis of agricultural policy to support resource-saving agriculture for the intensification of sustainable production. TOO Jarkın Ko, Astana-Shortandy, pp. 312–315.

Choudhary AK, Jain SK, Dubey AK, Kumar J, Sharma M, Gupta KC, Sharma LD, Prakash V, Kumar S (2022). Conventional and molecular breeding for disease resistance in chickpea: Status and strategies. *Biotechnol. Genet. Eng. Rev*. 39(2): 193–224. https://doi.org/10.1080/02648725.2022.2110641.

Demchenko MV (2011). Yield and feed value of the products of mixed chickpea-barley crops. *Teoreticheskiii nauchno-prakticheskii Zhurnal Izvestiia* 1(29): 42–44.

Dospekhov BA (2012). Methodology of Field Experiments (with basic statistical analysis of research results). Al'yans, Moscow, pp. 352.

Elunin NS (2014). Chickpea cultivation using various technologies in the West Kazakhstan region. In: Collection of scientific papers dedicated to the 85th anniversary of the founding of the Karabalyk Agricultural Society. Karabalykskaya SKHOS, Nnauchnyy, pp. 220–223.

Germantseva NI, Kalinina GV, Selezneva TV (2009). The role of the world collection in the selection of chickpea. In: Collection of scientific works dedicated to the 135th anniversary of G.K. Meister and the 100th anniversary of the founding of the Arkadak Experimental Station. OOO Rakurs, Saratov, pp. 137–141.

Gummatov NG (2017). Changes in the agrophysical qualities of soils during the growing season of grain legumes in the dryland conditions of Azerbaijan. In: Difficulties in nature management and the natural situation in the European Russian Federation in adjacent zones: Proceedings of the VII International scientific conference (in memory of Prof. A.N. Petin). Politerra, Belgorod, pp. 125–129.

Gurumurthy S, Singh J, Basu P, Meena S, Rane J, Singh N, Hazra K (2022). Increased significance of chickpea (*Cicer arietinum* L.) senescence trait under water-deficit environment. *Environ. Chall*. 8, 100565. https://doi.org/10.1016/j.envc.2022.100565.

Guz GV, Aituev ZhI (2004). Chickpeas of the Ural Region. In: Promising directions of stabilization and development of the agro-industrial complex of Kazakhstan in modern conditions. Uralsk, pp. 163–167.

Jain N, Babbar A, Kumawat S, Yadav RK, Asati R (2022). Correlation and path coefficient analysis in the promising advance chickpea lines. *Pharm. Innov*. 11(5): 2124–2128.

Jha UC, Nayyar H, Thudi M, Beena R, Prasad PVV, Siddique KHM (2024). Unlocking the nutritional potential of chickpea: Strategies for biofortification and enhanced multinutrient quality. *Front. Plant Sci.* 15:1391496. https://doi.org/10.3389/fpls.2024.1391496.

Kashevarov N, Bodiagin (2010). Chickpea as a promising grain legume in Khakassia. *Glavnyi zootekhnik* 12: 20–25.

Kaur S, Gonçalves-Vidigal MC, Davidson J, Mysore KS, Pandey AK (2023). Editorial: Disease and pest resistance in legume crops. *Front. Plant Sci*. 14. https://doi.org/10.3389/fpls.2023.1166387.

Khaliq I, Moore K, Sparks AH (2022). The relationship between natural rain intensity and Ascochyta blight in chickpea development. *Eur. J. Plant Pathol*. 164(3): 313–323. https://doi.org/10.1007/s10658-022-02538-2

Kiseleva TS, Rzaeva VV (2019). The reserves of available moisture in the cultivation of chickpea in the northern forest-steppe of the Tyumen region. *Agrar. Bull. Urals* 9(188): 2–7.

Korbu L, Fikre A, Tesfaye K, Funga A, Bekele D, Ojiewo CO (2022). Response of chickpea to varying moisture stress conditions in Ethiopia. *Agrosyst. Geosci. Environ*. 5(1). https://doi.org/10.1002/agg2.20234.

Kudapa H, Ghatak A, Barmukh R, Chaturvedi P, Khan A, Kale S, Fragner L, Chitikineni A, Weckwerth W, Varshney RK (2024). Integrated multi-omics analysis reveals drought stress response mechanism in chickpea (*Cicer arietinum* L.). *Plant Genome* 17(1):e20337. https://doi.org/10.1002/tpg2.20337.

Kuptsov NS, Boris II (2008). Leguminous crops and their importance in the agricultural production of Belarus. *Belarus. Agric. J*. 1: 8–11.

Liu Y, Zhu S, Li Y, Sun F, Huang D, Chen X (2023). Alternations in the multilevel structures of chickpea protein during fermentation and their relationship with digestibility. *Food Res. Int.* 165:112453. https://doi.org/10.1016/j.foodres.2022.112453.

Medvedev GA, Utuchenkov SI (2010). Yields of grain legumes with various primary tillage in the Southern chernozems of Volgograd Oblast. *Volgograd State Agric. Acad. AIC Bull.* 1: 15–18.

Namazbekova S, Samsaliev AB, Chakaeva ASh (2022). Chickpea diseases in the Chui Valley of Kyrgyzstan. *KNAU Bull*. 1(60): 27–30.

Paul P, Patil SS, Manojkumar N, Gandhi MK (2022). Study of correlations and path evaluations to find yield contributing characters in chickpea genotypes. *Int. J. Environ. Clim. Chang*. 83–90. https://doi.org/10.9734/ijecc/2022/v12i830725.

Rozhanskaia OA, Kurkova SV (2014). Problems of chickpea (*Cicer arietinum* L.) harvest formation in West Siberia. In: Collection of scientific works dedicated to the 80th anniversary of the Kazakh Research Institute of Agriculture and Crop Production. Almalybak, pp. 351–354.

Rzaeva VV, Lakhtina TS (2018). Chickpea cultivation in the Northern forest-steppe of Tyumen Oblast. *Izv. Orenburg State Agrar. Univ.* 5(73): 87–90.

Sachdeva S, Bharadwaj C, Patil BS, Pal M, Roorkiwal M, Varshney RK (2022). Agronomic performance of chickpea affected by drought stress at different growth stages. *Agronomy* 12(5): 995. https://doi.org/10.3390/agronomy12050995.

Sagan VV, Iskakov RK (2014). Ecological variety testing of foreign and domestic lentil and chickpea varieties in the conditions of the 1st zone of Kostanay region. In: Collection of scientific papers dedicated to the 85th anniversary of the founding of the Karabalyk Agricultural Society. Karabalykskaya SKHOS, Nnauchnyy, pp. 77–79.

Shektybaeva GKh, Limanskaia VB, Kasenova AS (2021). 'Derkul' as a promising variety of chickpea. In: Collection of scientific works dedicated to the 30th anniversary of the independence of the Republic of Kazakhstan: Results. Achievements. Looking to the future. Zhangir Khan West Kazakhstan Agrarian-Technical University, Uralsk, pp. 61–67.

Skokbaev SO (2002). Methodology of State Variety Testing of Agricultural Crops. Almaty, pp. 378.

Takele E, Mekbib F, Mekonnen F (2022). Genetic variability and characters association for yield, yield-attributing traits and protein content of lentil (*Lens culinaris* Medikus) genotype in Ethiopia. *CABI Agric. Biosci*. 3(1). https://doi.org/10.1186/s43170-022-00079-6.

Tiwari G, Singh S, Kumar S, Singh P (2023). Screening and selection of drought-tolerant high-yielding chickpea genotypes (*Cicer arietinum* L.) under water stress. Life 13(6):1405. https://doi.org/10.3390/life13061405.