Ecological variety testing of chickpeas in a changing climate in the West of Kazakhstan

G.H. Shektybayeva, *V.B.* Limaskaya*, *A.T.* Orynbayev, and *A.S.* Kasenova

Uralsk Agricultural Experimental Station LLP, Uralsk, Republic of Kazakhstan

Abstarct. This research was carried out within the framework of the scientific and technical program BR10765000 "Creation of highly productive varieties and hybrids of leguminous crops based on the achievements of biotechnology, genetics, physiology, biochemistry of plants for their sustainable production" under the budget program 267 "Increasing the availability of knowledge and scientific research". The article presents the results of ecological variety testing of chickpeas in the arid conditions of Western Kazakhstan. The West Kazakhstan region sharply differs in soil and climatic conditions from other regions of Kazakhstan. Naturally, in such difficult environmental conditions, varieties that will be able to fully solve the problem of overcoming the negative complex influence of limiting environmental factors that are strictly specific to a particular zoning zone become crucial. Among leguminous crops, chickpea occupies a leading position as a source of vegetable protein and has very high nutritional value. Moreover, its value lies in its ability to improve soil fertility by enriching it with nitrogen. Chickpea is an excellent precursor to spring durum wheat. The main goal of this scientific work is to systematically study chickpea breeding material, identifying sources of valuable traits and properties through ecological selection, and creating new competitive and patentable varieties adapted to the agroecological conditions of our region. The article presents a summary of the results of ecological variety testing of chickpea breeding carried out by various research institutes including the Kazakh Research Institute of Agriculture and Plant Breeding, Krasnokutsky Breeding and Experimental Station, Volgograd State Agricultural Academy, Krasnovodopadsky Agricultural Experimental Station, and the Scientific and Production Center of grain economy named after A.I. Baraev.

1 Introduction

Due to the diversification of agricultural production, farmers in the Republic are paying great attention to the possibilities of cultivating leguminous crops, with the most common being chickpeas.

Currently, animal husbandry is undergoing intensive development in the Republic, which increases the annual need for feed in agriculture. Leguminous crops, especially

* Corresponding author: ucxoc1914@mail.ru

chickpeas, which contain from 25 to 30% protein with a high content of essential amino acids, primarily lysine, play a significant role in addressing the problem.

The problem of vegetable protein cannot be solved without the use of the most productive and high-protein chickpea varieties. Therefore, creating chickpea varieties that are resistant to adverse environmental conditions is a very urgent task.

The problem of vegetable protein cannot be solved without increasing legume production. In the dry-steppe zone of dark chestnut soils in Western Kazakhstan, chickpeas are the main leguminous crop. Compared to other legumes, chickpeas are characterized by high drought resistance and productivity, have an erect non-overlapping stem, high attachment of the lower beans, can be removed by conventional grain harvesters, and are slightly damaged by pests [1, 2, 3, 4, 5, 6].

Chickpeas have significant feed advantages, and their value lies in improving soil fertility by enriching it with nitrogen. Chickpeas are an excellent precursor to spring durum wheat. According to numerous studies, the yield of durum wheat sown after chickpeas is 25% higher than after winter wheat [6, 7, 8, 9, 10, 11, 12, 13, 14].

New varieties play a big role in increasing yields. Two varieties of chickpeas have been zoned in the West Kazakhstan region: Jubilee, a selection of the Krasnokut breeding experimental station (zoned in 1967) and Volgograd 10, a selection of the Volgograd State Agricultural Academy (zoned in 1990).

Chickpeas have always been an insurance crop for Western Kazakhstan. Therefore, the search for new, more productive, and economically valuable adapted varieties of this crop is currently relevant and requires extensive scientific research [15, 16, 17, 18, 19, 20].

In this regard, an ecological test of chickpea varieties has been launched at “Uralsk Agricultural Experimental Station” LLP, according to the budget program “Creation of highly productive varieties and hybrids of leguminous crops based on the achievements of biotechnology, genetics, physiology, biochemistry of plants for their sustainable production in various agrozones of Kazakhstan”, to isolate the most adapted variety for the West Kazakhstan region.

2 Material and methods of research

The research was carried out at the Ural Agricultural Experimental Station. The results of ecological variety testing of chickpea selection conducted by the Kazakh Research Institute of Agriculture and Plant Breeding, Krasnokutsky Breeding and Experimental Station, Volgograd State Agricultural Academy, Krasnovodopadsky Agricultural Experimental Station, and Scientific and Production Center of Grain Farming named after A.I. Barayev are given for conducting scientific research. In this nursery, these varieties are evaluated according to the main economically valuable characteristics. The yield, some elements of grain quality, and indicators of biometric accounting are provided, along with the analysis of the crop structure for 3 years (2020-2022).

Currently, work is underway at the Uralsk Agricultural Experimental Station to evaluate and identify the best chickpea varieties in nurseries of ecological variety testing adapted to the arid conditions of Western Kazakhstan. Fifty chickpea numbers have been studied at the “Uralsk Agricultural Experimental Station” LLP from 2020-2022. One of the areas of cooperation with research institutions of Kazakhstan and Russia is the exchange of varieties and lines for their study.

The main production crops of chickpeas in the region are zoned, with the Yubileyny chickpea variety and the Volgograd 10 chickpea variety zoned since 1967 and 1990, respectively. These varieties no longer meet all the requirements of modern production and need to be replaced by new varieties that are more productive, drought-resistant, and have a complex of economically valuable features.

3 Results and their discussion

The experiments were conducted on a non-irrigated site of the Department of Breeding and Primary Seed Production at "Uralsk Agricultural Experimental Station" LLP in the selection and seed crop rotation. The soils of the experimental site are dark chestnut heavy loamy, with an arable horizon containing 2.74% humus. The availability of mobile forms of phosphorus is average, ranging from 13.7 to 16.3 mg/kg of soil. The content of alkaline hydrolyzable nitrogen is very low, at 25 mg/kg, while exchangeable potassium is high, at 466 mg/kg of soil.

The experiment was carried out following the spring wheat predecessor in the selection and seed crop rotation. Pre-sowing tillage consisted of surface treatment with a cultivator and a tillage tool-4.25, followed by rolling with ring-spur rollers.

Sowing was performed using a self-propelled seeder "Wintersteiger TC", depending on the weather conditions of the year, in the first decade of May. The estimated seeding rate for chickpeas was 0.8 million germinating grains per 1 ha. The depth of seeding was 6-7 cm. After sowing, the soil was rolled by rollers with a three-section ring-spur roller-6. The seedlings were harrowed across the rows.

The main limiting factor in increasing the yield of crops cultivated in the region is moisture.

The weather conditions during the 2020-2022 research period fully reflected the features of the continental climate of the West Kazakhstan region. In 2020, precipitation in April was 17.7 mm, which was 4.3 mm less than the normal rate of 22 mm. In May, the precipitation was 15.2 mm, which was 12.8 mm less than the normal rate of 28 mm. The temperature in July was 26.1°C, which was higher than the normal rate of 22.9°C. In 2021, the temperature regime in the first months of the growing season (May, June) exceeded the norm by 34% and 17%, respectively. The average daily temperature in May was 21°C, compared to the normal rate of 16°C, and in June, it was 24.5°C, compared to the normal rate of 20.9°C.

The stressful situation was improved by a multi-day rain that occurred at the end of May, coinciding with the beginning of the shoots phase. From May 30 to June 4, 89 mm of precipitation fell over six days. However, the subsequent continuous dry air led to a loss of moisture in the soil. In June, there was a continuous drought for 25 consecutive days, with daytime temperatures ranging from 33.5 to 41.8°C, and soil temperatures of 50-55°C. From June 15 to June 30, the average daily air temperature was 28.8-31.9°C, compared to the long-term norm of 20.9°C. No precipitation occurred during this period. Thus, the formation of the vegetative mass of plants occurred under extreme conditions of atmospheric and soil drought.

In July, the situation did not change. The average daily temperature was 25.1°C with a norm of 22.9°C. Precipitation only reached 17 mm compared to the norm of 40 mm. The end of July and the beginning of August were also not comforting: no precipitation, the average daily temperature was 28.2-29.5°C compared to the long-term data of 22.9-21.2°C. Daytime temperatures reached 38-42°C. The deviation of the average daily temperature in July was +2.2°C, and in August, it was +4.9°C. The lack of precipitation in July was -23 mm, and in August, not a single millimeter fell, respectively -27 mm. The chickpea crops also experienced extreme conditions during grain filling, resulting in puny and lightweight grain. The cold snap began only in September, with precipitation for the month reaching 33 mm compared to the monthly norm of 29 mm.

A sufficient amount of soil moisture, which was 110 mm by the time of sowing, and an active increase in positive temperatures at the end of May contributed to the production of friendly and early shoots. However, the increased temperature regime of the summer months negatively affected the chickpea harvest (July temperature was 25.1°C compared to

a norm of 22.9°C). In August, the air temperature sharply rose to 26.0°C (norm 21.1°C) with a shortage of rain in July (17 mm compared to a norm of 40 mm) and no precipitation in August (0 mm compared to a norm of 27 mm) (Table 2).

The temperature regime during the first months of the growing season of 2022 was also unstable. In April, there was an excess of heat by 3.5°C, and in May, there was a shortage of 3.6°C. Precipitation fell within the norm in April (22 mm) and exceeded the norm in May (38.2 mm compared to 28 mm). Overall, the spring was long, cool, and accompanied by cold rains.

According to the meteorological conditions, the continuous air drought of June-July months led to a loss of moisture in the soil. Precipitation in June only reached 8.0 mm compared to the norm of 33.0 mm. Thus, the set (formation) of the vegetative mass of plants took place in extreme conditions of atmospheric and soil drought.

In the month of July, the situation did not change much. The average daily temperature was 23.2°C with a norm of 22.9°C. Precipitation only reached 15 mm compared to the norm of 40 mm. Starting from the third decade of July and throughout August, there was no precipitation. The average daily temperature in August was 24.2°C compared to the norm of 21.1°C. The deviation of the average daily temperature in July was +0.3 degrees, and in August, it was +3.1 degrees. The lack of precipitation in July was -25 mm, and in August, it was -25.9 mm. Precipitation in September reached 30.9 mm compared to the monthly norm of 29 mm (Table 1).

Table 1. Meteorological indicators of the chickpea growing season for 2020-2022 (according to the Uralsk meteorological post, https://rp5.ru/)

Years	Months	Indicators					
		precipitation, mm			air temprature, 0^0C		
		average month.	average long - term	deviation	average month.	average long - term	deviation
2020	april	17.7	22	-4.3	7.9	8.1	-0.2
	may	15.2	28	-12.8	17.0	16.0	+1.0
	june	56.6	33	+23.6	20.7	20.9	-0.2
	july	5.4	40	-34.6	26.1	22.9	+3.2
	august	16.9	27	-10.1	20.5	21.1	-0.6
	september	38.8	29.0	+9.8	8.8	14.5	-5.7
2021	april	29	22	+7	9.8	8.1	+1.7
	may	20	28	-8	21.5	16.0	+5.5
	june	69	33	+36	24.5	20.9	+3.6
	july	17	40	-23	25.1	22.9	+2.2
	august	0	27	-27	26.0	21.1	+4.9
	september	33	29	+4	13.4	14.5	-1.1
2022	april	22	22	0	11.6	8.1	+3.5
	may	38.2	28	+10.2	12.4	16	-3.6
	june	8.0	33	-25.0	20.9	20.9	0
	july	15.0	40.0	-25.0	23.2	22.9	+0.3
	august	1.1	27.0	-25.9	24.2	21.1	+3.1
	september	30.9	29.0	+1.9	15.5	14.5	+1.0

The years 2020 - 2021 were more favorable. Grain yield in 2020 ranged from 14.4 to 18.9 c/ha, in 2021 from 18.2 to 21.7 c/ha, in 2022 from 10.3 to 14.0 c/ha.

For three years, the yield of grain of the Jubilee standard in the experiment with a harvesting humidity of 14% was 13.2 c/ha. A significant excess in this indicator was obtained in 19 varieties, including varieties and varietals with an excess of 1.5-4.5 c/ha: Privo 1, G 97-121, G 97-60, G 02-10 (Table 2).

Table 2. Grain yield (c/ha) and the main elements of the chickpea crop structure in the ecological nursery for 2020-2022

Breed	Grain yield, c/ha by year				In % to the standard	Weight of 1000 grains, g.	Number of beans per 1 plant, pcs.	Grain output from a sheaf, %
	2020	2021	2022	Average				
Jubilee, st.	12.2	13.6	10.8	13.2	100	244.7	68.5	48.0
Privo 1	18.9	20.5	13,7	17.7	134.1	262.1	78.1	48.9
F 97-121	18.5	21.3	12,4	17.4	131.8	285.5	69.4	57.3
F 97-60	17.4	20.2	14,0	17.2	130.3	277.0	78.4	51.8
F 02-10	18.0	21.7	11,3	17.0	128.7	278.3	77.3	62.7
F97-50	17.7	19.5	13,5	16.9	128.0	257.5	61.4	50.6
ZK-7	17.0	20.4	13,0	16.8	127.2	254.6	71.6	67.9
F 98-30	16.7	19.2	12,7	16.2	122.7	259.9	61.2	77.0
13-B	16.2	20.1	11,7	16.0	121.2	260.4	56.2	43.7
TH 45/01	17.0	19.8	11,2	16.0	121.2	255.2	59.8	52.3
ZK-8	15.1	20.6	12,0	15.9	120.4	223.4	61.6	46.9
Er Sultan	16.2	19.4	11,8	15.8	119.6	252.4	69.4	57.3
Karabaliksky 1	15.4	19.1	12,3	15.6	118.1	264.2	78.4	51.8
F 92-52	14.8	19.6	12,4	15.6	118.1	258.0	77.3	62.7
F 99-55	14.2	20.1	12,2	15.5	117.4	254.6	61.4	50.6
F 02-79	15.0	19.4	11,8	15.4	116.6	262.7	71.6	67.9
Bonys	14.4	19.7	11,5	15.2	115.1	275.0	61.2	77.0
Derkul	16.2	18.2	10,6	15.0	113.6	266.4	56.2	43.7
F 03-153	14.8	19.1	10,8	14.9	112.8	280.0	59.8	52.3
Volgogradski 10	15.1	18.7	10,3	14.7	111.3	267.3	61.6	46.9
$LSD_{0.5}$				**0.7**	**11.8**	**25.7**	**6.5**	**5.3**

The absolute grain weight of the standard averaged 244.7 g. All the varieties that stood out in terms of yield had a fairly high mass index of 1000 grains: 285.5 g in the variety type G 97-121, 280.0 g - F 03-153,278,3g - F 02-10.

According to the research data of the Krasnokutsk Agricultural Experimental Station [2], chickpeas are much superior to barley, the main grain crop in our zone, in terms of the yield of digestible protein. 100 kg of chickpea grain contains 19.5 kg of digestible protein, 100 kg of barley – 8.5 kg. Chickpea protein is characterized by a high content of essential amino acids, primarily lysine. In 1 kg of chickpea grain, its content is 31.8 g.

According to the yield of feed units, 4 varieties of chickpeas were the most productive. In the standard and other varieties, the yield of feed units was 1.27 each (Table 3).

Table 3. Characteristics of the main chemical indicators in chickpea grain for 2020-2022

Grade	Fodder units	Digestible protein, g/kg
Jubilee, st.	1.27	23.0
Privo 1	1.32	24.2
Er Sultan	1.30	23.0
ZK-7	1.32	24.2
Derkul	1.30	22.8

The content of digestible protein in the grain of the Jubilee standard was 23 g/kg. These indicators are higher in the varieties Privo 1 and ZK-7.

4 Conclusions

According to the results of the ecological variety testing of leguminous crops of domestic and foreign selection from 2020 to 2023, chickpea varieties will be transferred to State Variety Testing in 2023.

Four varieties of chickpeas were selected for 2020-2022: Privo 1, G 97-121, G 97-60, G 02-10. These varieties practically do not lodge, have excellent indicators in terms of maturation, and resistance to shedding. They are characterized by high suitability for mechanized harvesting, with the height of attachment of the lower beans at 20.2 cm. These varieties showed the highest results in several indicators of productivity, precocity, and protein content.

Based on the ecological variety testing of chickpeas in the arid conditions of Western Kazakhstan, a number of samples were identified based on economically valuable characteristics. These samples will serve as valuable source materials for practical breeding. Currently, work is ongoing at the Uralsk Agricultural Experimental Station to evaluate and identify the best chickpea samples in nurseries of ecological variety testing adapted to the arid conditions of Western Kazakhstan.

References

1. B.B. Sagan, R.K. Iskakov, *Ecological variety testing of foreign and domestic varieties of lentils and chickpeas in the conditions of the 1st zone of the Kostanay region*, Collection of scientific papers dedicated to the 85th anniversary of the birth of Karabalykskoy SHOS, 77-79.
2. A.N. Checherina, Bulletin of Agricultural Science of Kazakhstan, **2**, 20-23 (2013)
3. G.H. Shektybayeva, V.B. Limanskaya, A.S. Kasenova, *Promising chickpea variety "Derkul", Collection of scientific papers dedicated to the 30th anniversary of the independence of the Republic of Kazakhstan: Results,* Achievements. A look into the future. Scientific and practical journal of WKATU named after Zhangir Khan "Science and Education" 09.12, 2021, 61-67.
4. M.A. Berdagulov, K.I. Iskakov, V.A. Chudinov, E.V. Shilo, Scientific support for the production of competitive agricultural products, (2009)
5. O. Bushulyan, V. Sichkar, Agriculture, **7** (2011)
6. N.I. Germantseva, G.V. Kalinina, T.V. Selezneva, *The role of the world collection in chickpea breeding*, Collection of scientific papers dedicated to the 135th anniversary of G.K. Meister and the 100th anniversary of the founding of the Arkadak Experimental Station. GNU Research Institute of Agriculture of the South-East. Saratov, 137-141 (2009)
7. O.A. Rozhanskaya, S.V. Kurkova, *Problems of formation of the chickpea crop (Cicer arietinum) in Western Siberia*, Collection of scientific papers dedicated to the 80th anniversary of the Kazakhstan Research Institute of Agriculture and Plant Industry, Almalybak, 351-354 (2014)
8. M.V. Demchenko, Theoretical and scientific-practical journal Izvestia, **1 (29)**, 42-44 (2011)
9. N.S. Elunin, *Chickpea cultivation with various technologies in the West Kazakhstan region*, Collection of scientific papers dedicated to the 85th anniversary of the birth of the Karabalyk SHOS, 220-223.
10. S.G. Chekalin, V.B. Limanskaya, Agro-resource potential of chickpeas in Western Kazakhstan: in the collection: Know-till and fruit change - the basis of the agrarian

policy to support resource-saving agriculture for the intensification of sustainable production, Astana-Shortandy, 312-315 (2009)

11. G.V. Guz, Zh.I. Aituev, *Chickpeas of the Uralsk: in compilation: Perspective directions of stabilization and development of the agro-industrial complex of Kazakhstan in modern conditions,* 163-167 (Uralsk, 2004)
12. S. Namazbekova, A.Sh. Chakaeva, *Chickpea diseases in the Chui valley of Kyrgyzstan,* (Bulletin of KNAUIM, K. Scriabin, Bishkek, 2017)
13. N. Kashevarov, Y. Bodyagin, GNU Research Institute of Agrarian Problems of Khakassia SO RAAS. Chief livestock specialist, **12**, 20-25 (2010)
14. G.A. Medvedev, S.I. Utuchenkov, Volgograd State Agricultural Academy, APK Bulletin, **1**, 15-18 (2010)
15. V.V. Balashov, A.V. Balashov, N.A. Kulikova, A.M. Khabarov, *Features of the cultivation technology of chickpea varieties of Volgograd selection*, Proceedings of the international scientific-practical conference "Scientific support for the development of the agro-industrial complex of the countries of the customs union", 147-152 (FGOU Volgograd State Agricultural Academy. Astana, 2010)
16. N.S. Kuptsov, I.I. Boris, RUP " NPC NAN Belarusian agriculture, **1**, 8-11 (2008)
17. N.I. Germantseva, G.V. Kalinina, T.V. Selezneva, The role of the world collection in chickpea breeding, Collection of scientific papers, dedicated. 135th anniversary of G.K. Meister and the 100th anniversary of the founding of the Arkadak Experimental Station, 137-141 (GNU NIISH of South-East, Krasnokutskaya AES, Saratov, 2009)
18. V.V. Rzayeva, T.S. Lakhtina, Proceedings of the Orenburg State Agrarian University, **5 (73)**, 87-90 (2018)
19. N.G. Gummatov, *Changes in the agrophysical qualities of soils during the growing season of leguminous crops in the rainfed conditions of Azerbaijan*, Difficulties in nature management and the natural situation in the European Russian Federation and in adjacent zones: materials of the V11 International Scientific Conference (in memory of Prof. A.N. Petin) 125-129 (2017)
20. T.S. Kiselev, V.V. Rzayeva, Agrarian Bulletin of the Urals, **9 (188)**, 2-7 (2019)