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CHICKPEA GENOTYPE SELECTION BASED ON ECONOMICALLY VALUABLE TRAITS TO DEVELOP HIGH-YIELDING TYPES

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SUMMARY

In breeding chickpeas (*Cicer arietinum* L.), the prime objective is high-protein genotypes' development for a balanced diet with plant-origin products. The pertinent research also aimed to develop drought-resistant and highly productive chickpea cultivars with better quality, adapting well to the soil and climatic conditions of Kazakhstan. The article summarized the results of many years of research on chickpea world collection in the dry-steppe and foothill zones of Southeast Kazakhstan. Chickpea genotypes' characterization has included as essential base material for subsequent breeding programs with specific economically valuable traits, i.e., early maturity, high-seed productivity, seed size, plant height, height of the lower pods, and shape of the bush. In the collection nursery, 223 chickpea cultivars incurred analysis. A structural analysis ensued based upon the following characteristics, i.e., the bush structure, plant height, height of the lower pods, the number of lateral branches, the number of productive nodes, the number of pods per plant, seed weight per plant, and 1000-seed weight. On the flowering and maturity period, 132 chickpea samples were at the standard level, for which the period was 80–88 days, while 62 genotypes matured 5–6 days earlier than the standard. The use of 13 drought-resistant genotypes, i.e., 12216, 12227, 12118, 3046, 12125, 12108, 12119, 31107, 42134, 31105, 31108, 31232, and 42145 was necessary to enhance the chickpea productivity with quality through hybridization program. Overall, the study identified 42 chickpea cultivars based on growth and yield traits for chickpea breeding under the environmental conditions of Southeast Kazakhstan.

Keywords: Chickpea (*Cicer arietinum* L.), world collection, conventional breeding, hybridization, drought resistance, growth and yield traits, selection, Southeast Kazakhstan

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Key findings: Through the chickpea (*Cicer arietinum* L.) breeding program, identifying drought-resistant, highly productive, and better-quality genotypes was successful. Based on the economically valuable and quality properties, the selected genotypes will serve in the parental genotypes' selection for crossing through conventional hybridization.

INTRODUCTION

Leguminous crops are the most important flowering plants, useful for human and animal foods and as soil-improving components of the agriculture system (Qulmamatova, 2023). Legumes are an essential and specific component of the structure of sown areas in crop production. For providing the population with high-quality food products and animal husbandry with feed, the legumes offer a high level of diversification, help preserve soil fertility, reduce the dependency on mineral nitrogen fertilizers, and provide environmentally friendly food products. With the above, legumes become in demand with all types of ownership and equally crucial under diverse climatic conditions (Zotikov *et al*., 2016; Gryadunova and Khmyzova, 2018; Polukhin and Panarina, 2020). Diversifying crop rotation with pulses can improve soil fertility and support enhancing crop yields. Including the pulses in crop rotation has significantly increased the yield of major crops in the long term (Probir *et al*., 2016; Hegde *et al*., 2018; Hussain *et al*., 2022).

In leguminous crops, the chickpea (*Cicer arietinum* L.), considered a leader in drought and heat resistance, is particularly interesting to commodity producers. Chickpea is one of the most drought-resistant and heat-tolerant crops that is a good predecessor (Vasilchenko and Metlina, 2020). The source material for developing the new cultivars can be a worldwide collection of chickpea genotypes from different ecological and climatic zones (Vishnyakova *et al*., 2019; Sokolkova and Bulyntsev, 2020).

The Almaty region makes it possible to identify valuable source material for priority breeding areas in assessing chickpea genetic resources in a peculiar zone for cultivation in dry steppes. Based on the obtained observations, proposing priority use of genotypes of the first cluster in breeding programs for developing chickpea cultivars for the gaff lands of Southeast Kazakhstan arose (Vus *et al*., 2020). The chickpea productivity relies upon the genetic characteristics of the cultivars and the environmental conditions. The ability of a genotype to achieve high and stable yields has the genotypic resistance to unfavorable environmental factors primarily determining it (Zotikov *et al*., 2016; Maqbool *et al*., 2017; Wadhwa *et al*., 2017).

According to Khasanova *et al*. (2020), in connection with the complex weather and climatic conditions of Northern Kazakhstan, there is a need to expand the cultivation of drought-resistant crops capable of economical consumption of moisture when it is lacking in the soil and air. The article uses several laboratory methods for appraising drought resistance, allowing for considering the problem from various angles and studying the mechanism of drought resistance. The research reflected chickpea plants' adaptation to drought with the help of stomata and their water-holding capacity. The experiment commenced on 19 chickpea samples from an international collaboration with the ICRISAT collection.

In Kazakhstan, chickpeas are grown on 20,000 hectares (Suleymanova *et al*., 2023). Additionally, enhancing chickpea production in Kazakhstan may correlate with providing new jobs and increased income levels of agricultural workers, which could positively impact the country's socio-economic development. In Kazakhstan, chickpea production is an outstanding agriculture sector with significant commercial importance for the country's economy. According to statistical data obtained from the Republic of Kazakhstan (2021–2022), the chickpea sowing area was more than 20,000 hectares, and grain production was 35,000 tons, with an average chickpea yield of 8–15 c/ha (Soybean area in Kazakhstan, 2023). In addition, chickpea production is economically vital for Kazakhstan, as it is one of the country's leading export products. According to the 2021 FAO report, Kazakhstan was the fourth-largest chickpea producer in the world, after India, Turkey, and Mexico (FAO, 2021). In the study of 2020 by the United Nations Population Office in Kazakhstan, chickpea production can favorably impact sustainable development as the grain is less water-intensive and more resilient to climate change than other crops (UN - Annual Report in Kazakhstan, 2020).

At the West Kazakhstan Agricultural Technical University, resulting from five years of research in grain-fallow crop rotation, the chickpea yield was 0.5 t/ha higher than barley, millet, and wheat, amounting to 1.08 t/ha. For some crop seasons, the chickpea yield could reach up to 2 t/ha (Vyurkov, 2006). The presented research also aimed to develop drought-resistant and highly productive chickpea (*C. arietinum* L.) cultivars with better quality, adapting well to Kazakhstan's soil and climatic conditions.

Interest in chickpeas in Kazakhstan has been increasing in recent years due to its diversification and profitability of crops, improvement of soil conditions, and profitable cultivation in economic terms. The State Register of Varieties admitted to the production of the Republic of Kazakhstan includes 13 chickpea varieties, 10 of them of domestic selection, which are prone to diseases in unfavorable years, leading to a decrease in their yield. With the growing interest in the culture on the part of commodity producers, it is a must to create chickpea varieties resistant to common diseases. The most harmful chickpea disease in Southeast Kazakhstan is ascochytosis (*Ascochyta rabiei* Pass.), affecting leaves, stems, beans, and seeds with intense infection, and the crop almost completely dies, especially in humid years. The susceptibility to ascochytosis of modern varieties of local breeding is the chief barrier to expanding the cultivation area of this crop in the Republic. In this regard, the role of studying the world collection as a source material for breeding is increasing (Taskinbayeva *et al*., 2022).

Past studies described the breeding state of modern chickpeas in the fields of Krasnovodopad Agricultural Experimental station, where the breeding work of chickpeas is leading (Orazaliyev *et al*., 2022). In 2021, 220 chickpea varieties of Krasnovodopadsky Agricultural Cooperative LLP bore testing at the entire nursery, isolating samples with a productivity of less than standard. During the scientific study, 15 chickpea samples identification relied on early germination, 20 samples by growth intensity, 10 samples by branching, 16 samples by early flowering, 10 samples by drought resistance, 10 samples by resistance to ascochytosis, making a structural analysis, and 21 samples by yield. The selection-valuable signs appeared when growing collectible chickpea samples exposed to the study of the following stages. Currently, limited protein needs addressing in Kazakhstan. In resolving this situation, it is urgent to identify new varieties of chickpeas that give more yield for the further development of the agriculture industry.

The article highlighted specimens by various economically valuable features in studying chickpea samples. Studies on early germination of samples, growth rates, branching, flowering dates, early ripening, drought resistance, and yield progressed, resulting in the following samples obtained for early flowering: F10-263c, F10-100c, F10-76c, F10-159c, F10-92c, F10-183c, F97-101c, F97-50c, F97-81C, F97-12C, F97-19c, F97-65c, F97-81c, and F97-95c. Samples F97-103c and F97-114c prevailed over the Symbat-1 variety in yield by 0.3–1.3 c/ha. According to the intensity of growth, 20 samples attained distinction, including F97-171, F98-10, F98-88, F98-12, F98-25, and other varietal samples exceeding 1 grade of the standard grade for 1–2 days.

The article presents theoretical justifications and practical results of attracting leguminous crops, such as soybeans, peas, chickpeas, and lentils, in the genetic resources' collection over the past 15 years. Accounting for current requirements of the present time and the agro-climatic potential of the country over the years, about 1,500 samples have been part of the collection: local and breeding forms with known properties, as well as newly introduced varieties from abroad. It is advisable to point further expansion of work in this direction, firstly, to study the features of inheritance of resistance to biotic and abiotic stressors to develop adequate genetic systems for their control. Global climate changes toward warming indicate that much larger territories have periodic exposure to drought. In this regard, in agriculture, there is a need to expand the cultivation zone of drought-resistant crops, which include chickpeas and lentils. In the current areas of breeding, we have created new varieties of chickpeas, "Jamila," and lentils, "Jasmine," which gained successful implementation in the Republic's production (Shikhalieva and Mirzoev, 2023).

MATERIALS AND METHODS

Breeding material and procedure

The chickpea (*C. arietinum* L.) breeding research has been ongoing since 1991 at the LLP Kazakh Research Institute of Agriculture and Plant Growing, Almaty region, Kazakhstan. The collection nursery includes more than 223 chickpea genotypes procured from ICARDA-Syria, N.I. Vavilov All-Russian Institute of Plant Genetic Resources (VIR)-Russia, Institute of Genetic Resources, National Academy of Sciences-Azerbaijan, and other research institutions. The sown chickpea in the nursery had two replicates with a row length of 1 m^2, row spacing of 45 cm, and seed placement depth of 4–5 cm, with the standard cultivar sown after every 10 entries for comparison. The zoned chickpea cultivar, Kamila 1255, served as the check genotype in the experiment. Pre-sowing soil preparation during the years of studying the collection was customary for all legumes, conducting the sowing at the optimal time. The study continued following the classifier of the genus *Cicer* L. and the methodological instructions of the VIR, Russia, for leguminous crops (Vishnyakova, 2010; Smaiylov, 2012). During the growing season of plants, phenological observations ensued. In analyzing productivity, 25 plants from each subplot of each repetition sustained random selection before harvesting. Harvesting occurred when the seeds reached complete and physiological maturity. Productivity recalculation had the standard humidity (14%).

Research on the study samples of leguminous crops happened in the foothill zone of Southeast Kazakhstan at the stationary site of the leguminous crops' laboratory of the Kazakh Scientific Research Institute of Agriculture and Plant Growing (KazRIAP), Kazakhstan. According to the meteorological station (KazRIAP), weather conditions during the study period were generally satisfactory for chickpea crop growing. Moderately warm weather with uneven precipitation prevailed. The air temperature in the spring and summer months was at the level of the long-term average data. During the summer months of June and July 2021, the precipitation was less (19.6–22.4 mm) versus the average long-term data (-34.5–4.2 mm). However, in August, the precipitation was higher (31.9 mm) than the average long-term (10.4 mm), which extended the development phases of chickpeas and helped assess the disease resistance of the genotypes under natural conditions. However, the rapid development of fungal diseases in legumes did not enable the recording of diseases.

RESULTS AND DISCUSSION

In the sown collection nursery, 223 chickpea (*C. arietinum* L.) genotypes attained analysis. The structural analysis depended on the following growth and yield-related parameters, i.e., the structure of the bush, plant height, height of the lower beans, the number of lateral branches, the number of productive nodes, the number of pods per plant, seed weight per plant, and the 1000-seed weight.

The growing season period was the most important biological and economic feature determining the chickpea genotypes' distribution area, adaptability, and production efficiency (Germentseva and Selezneva, 2014). The mathematically substantiated data for the conditions of the Volga region on the optimal duration of different periods of chickpea vegetation (Germentseva, 2001) and the period of germination – flowering for the Volga region should be 38–40 days, the period of flowering – ripeness 48–52 days, and the total duration of the growing season should be 88–92 days. In the presented studies, 132 chickpea genotypes appeared with a growth period of 79 to 88 days, 89 medium-ripened cultivars (90–97 days), and three late-ripening (more than 100 days), identified based on precocity. However, according to the flowering-ripening period, 132 chickpea genotypes were at the standard level, for which this period was 79–87 days. The 62 chickpea genotypes also ripened 5–8 days earlier than the check cultivar (Table 1).

Crop lodging is an undesirable sign. It deteriorates the light regime conditions of plants, disrupts the air circulation in the crops, causes the rotting process of the fallen mass, enhances the spread of diseases, complicates the harvesting process, and, eventually, leads to considerable losses. One of the signs verifying the creation of cultivars with less lodging is the plant height, and the dwarf cultivars have less lodging and are more responsive to fertilizers (Vishnyakova, 2010). According to the plant height observations, 26 chickpea genotypes, i.e., 30232, 23210, 23230, F97-147, F02-70, K-32213, K-546, 28-B, 32205, 12136, 32208, K-1615, 30231, 95-57, K-3481, K-546, Krasnakutsky-36, K-323, F03-34/1, 14-B, 42225, 1457, 32208, 94-25, 42240, and 482 were prominent, ranging from 35.2 to 42.8 cm (Table 2).

Along with the plant height and stem strength, one of the criteria for selecting a non-lying source material is the feature - the shape of the bush. It is also important to identify sources suitable for mechanized harvesting. After 5–6 weeks of germination, evaluating the plant type of the chickpea genotypes continued according to the shape of the bush. The 38 chickpea genotypes out of 180 mostly had a compact and erect bush shape, while five genotypes had a sprawling bush shape.

According to Kholod *et al*. (2013), based on the trait 'height of attachment of the lower pods,' the chickpea genotypes classification were as follows: low (<15 cm) in which the placement of pods was above the ground level in 10 samples naturally, scored 9.8% of the total. However, 72 genotypes have an average height of 16–20 cm of the lower pods above the soil level, and their percentage was 70.6%. The 20 chickpea genotypes had the highest location (>21 cm) with a percentage of 19.6%. However, in legumes, the suitability for mechanized harvesting also links with the height of attachment of the lower pods. On average, the said trait varied from 11.0 to 31.6 cm among the studied chickpea

Table 1. Characteristics of chickpea genotypes based on the precocity.

Chickpea genotypes	Date of sowing	Date of germination	Flowering	Maturation date	Vegetation period (days)
Standard Kamila	05.04	27.04	05.06	23.07	87
23233	05.04	27.04	28.05	15.07	79
F07-39	05.04	29.04	28.05	17.07	79
3120	05.04	27.04	28.05	15.07	79
12136	05.04	27.04	28.05	15.07	79
3368	05.04	27.04	28.05	15.07	79
30228	05.04	27.04	30.05	18.07	82
K-543	05.04	29.04	30.05	20.07	82
K-151	05.04	27.04	30.05	20.07	82
F14-46	05.04	27.04	30.05	20.07	82
14-B	05.04	27.04	03.06	23.07	87
95-57	05.04	27.04	03.06	23.07	87
F02-55	05.04	27.04	05.06	23.07	87
F98-30	05.04	27.04	05.06	23.07	87
F97-63	05.04	27.04	15.06	23.07	90
F02-70	05.04	27.04	15.06	23.07	90
K-118	05.04	27.04	15.06	23.07	90
32228	05.04	27.04	15.06	23.07	90

Table 2. Average values of the productivity elements of the chickpea collectible during 2021–2023.

Parameters	Values (ranges)	Names of chickpea genotypes	Number of genotypes
Plant height	35.2–42.8 cm	30232, 23210, 23230, F97-147, F02-70, K-32213, K-546, 28-B, 32205, 12136, 32208, K-1615, 30231, 95-57, K-3481, K-546, Krasnakutsky-36, K-323, F03-34/1, 14-B, 42225, 1457, 32208, 94-25, 42240, 482	26
Height of lower pods	25.0–31.6 cm	Vector, 30120, Zolotoy-Yubley, 30231, TASSAI, K-2616, 32208, K-1222, 14-B, 42225, 482, F97-30, F02-70, K-323, K-1615, 1457, Krasnakutsky- 36, 42240, K-546, 94 25, 28-B, K-546	22
Lateral branches plant^{-1}	4.2–9.0 #	31107, 23211, 30105, 12228, 12227, D84-14, 12119, D88-03, K-3570, F10-206C, 23226, 3046, 27-B, F07-39, 30-B, 482, 94-25, K-2483, D84-09, 23212, 23212, F06-11, 3333, D-8807, F10-86C, F05-11, 12114, 23233, 23216	29
Productive nodes plant^{-1}	21.0–35.2 #	F06-37, 23225, 23234, 12223, 12109, F05-33, K-3481, 30228, 12118, 31108, 12136, 31229, 3120, 12216, 42141, F97-24, 12129, 311 07, 23205, 31232, 2321, D84-14, 12233, 12233, 23211, F06-11, 12114, 23233, 23212,23212	30
Beans plant^{-1}	25.0–35.2 #	3120, 12216, 42141, F97-24, 12129, 31107, 23205, 31232, 23216, D84-14, 12233, 12233, 23211, F06-11, 12114, 23233, 23212,2321 2	18
Seed weight plant^{-1}	35.0–43.0 g	3312, K-3238, F97-126, 1457, 12227, 12106, 23232, 9487, 12109, 23216, 14-B, 2814, F02-70, Vector, 23210, 23224, k-1221, 27-B, F07- 80, Sharik, Krasnakutsky-36, K-1221, D-8420, 3018, 12233, 3050, K-3214, Zolotoy-Yubley, K-2801, F93-93S, F82-150C, 31105, D84-19, D84- 14, 12126, 23209, K-1783	37
1000-seed weight^{-1}	300.0–385.0 g	3018, K-3570, K-1783, D-8807, 3333, K-1221, 12233, D84-14, K-1446, K-288, D84-09, F88-85C, 14-B, F05-90, F06-76, 482, K-1783, K-3214, 23211, K-130, 12222, F10-86C, 3411, F14-46, K-32213, F10-206C, 482, 12228, 42145, 31232, 31108, 31105, 12119, 12108, 12125, 3046, 12118, 42134, 12227, 12216, 31107	42
Protein content	28.0%–33.5%	K-574, K-612, 2956, 2105, Miras 07, Nurly-80, K-1221,482, 510, K-2197, F98-50c	10

genotypes. The 22 chickpea genotypes combined, identified with the high attachment of the lower pods (>25.0–31.6 cm) included Vector, 30120, Golden-Yubley, 30231, TASSAI, K-2616, 32208, K-1222, 14-B, 42225, 482, F97-30, F02-70, K-323, K-1615, Krasnakutsky-36, 1457, 42240, K-546, 94-25, 28-B, and K-546 (Table 2).

Seed productivity determination occurred at the physiological maturity based upon the following parameters, i.e., the number of lateral branches, the number of pods and seeds on the plant, the seed weight per plant, and the 1000-seed weight. In 29 chickpea genotypes, the number of lateral branches varied from 4.2 to 9.0, i.e., 31107, 23211, 30105, 12228, 12227, D84-14, 12119, D88-03, K-3570, F10-206C, 23226, 3046, 27-B, F07-39, 30-B, 482, 94-25, K-2483, D84-09, 23212, 23212, F06-11, 3333, D-8807, F10-86C, F05-11, 12114, 23233, and 23216, with the said indicator at the standard level (Table 2). Allocating to the number of productive nodes are 30 chickpea genotypes, with the range of 21.0%–35.2%, viz., F06-37, 23225, 23234, 12223, 12109, F05-33, K-3481, 30228, 12118, 31108, 12136, 31229, 3120, 12216, 42141, F97-24, 12129, 31107, 23205, 31232, 2321, D84-14, 12233, 12233, 23211, F06-11, 12114, 23233, 23212, and 23212 (Table 2).

Shyurova (2002) believed that the potential biological yield of the chickpea cultivars is relatively high; however, its implementation depends upon internal and external factors. The number of pods and seeds per plant also varied greatly. On average, up to 40 or more generative organs attained formation on the plants during the growing season. In the future, most of them fall off, especially the buds and flowers. It was apparent that developing a potent root system is one of the most crucial factors of chickpea adaptation. According to present results, the number of pods per plant ranged from 25.0 to 35.2 in 18 chickpea genotypes, i.e., 3120, 12216, 42141, F97-24, 12129, 31107, 23205, 31232, 23216, D84-14, 12233, 12233, 23211, F06-11, 12114, 23233, 23212, and 23212 (Table 2).

High seed productivity was evident in 37 chickpea genotypes. The best productivity indicator was the seed weight per plant, ranging from 35.0 to 43.0 g, and resulting in the genotypes, i.e., 3312, K-3238, F97-126, 1457, 12227, 12106, 23232, 9487, 12109, 23216, 14-B, 2814, F02-70, Vector, 23210, 23224, k-1221, 27-B, F07-80, Sharik, Krasnakutsky-36, K-1221, D-8420, 3018, 12233, 3050, K-3214, Zolotoy-Yubley, K-2801, F93-93C, F82-150C, 31105, D84-19, D84-14, 12126, 23209, and K-1783 (Tables 2 and 3).

Based on the past experimental studies of Sarvliya and Godal (1994), a conclusion was that to increase chickpea productivity, first, it is necessary to enhance and improve the number of pods per plant and the 1000-seed weight because these are the chief yield-contributing traits in chickpea (Hegde *et al*., 2018; Hussain *et al*., 2022). Given the increased demand in the foreign market for large-seeded chickpea cultivars, the research on developing such cultivars further strengthened domestic breeding. Including large-seed sources in breeding programs will accelerate and boost the development of new large-seed cultivars of chickpeas. In the presented study, the chickpea genotypes showed distinction by a significant 1000-seed weight, one of the main components of seed productivity. Therefore, the best indicator of seed size and the 1000-seed weight (>300–385 g) exceeding the standard cultivar were the genotypes 3018, K-3570, K-1783, D-8807, 3333, K-1221, 12233, D84-14, K-1446, K-288, D84-09, F88-85C, 14-B, F05-90, F06-76, 482, K-1783, K-3214, 23211, K-130, 12222, F10-86C, 3411, F14-46, K-32213, F10-206C, 482, 12228, 42145, 31232, 31108, 31105, 12119, 12108, 12125, 3046, 12118, 42134, 12227, 12216, and 31107 (Tables 2 and 3).

Past findings revealed that a hot and dry climate with less precipitation accumulates more proteins in seeds than in plants growing in areas with a wet climate and low temperatures (Bulyntsev and Balashov, 2010; Qulmamatova, 2023). Present studies have shown that in chickpea seeds, the protein content varied from 11.5% to 33.5%, and this might be due to different weather conditions during the seed formation and filling stages. It was also noticeable that the higher the air temperature during the growing season, the more protein buildup in the seeds. From the 20 analyzed chickpea genotypes, 11 stood out, i.e., K-574, K-612, 2956, F98-50c, 2105, Miras 07, Nurly-80, K-1221, 482, 510, and K-2197, with the highest protein content in seeds (>28.0%) (Table 2, Figure 1.). Based on the economically valuable characteristics and properties, all the selected chickpea genotypes will serve in the parental pairs' selection for further crossing through conventional hybridization.

The main task of chickpea breeding is to study economically valuable traits that determine seed productivity and its quality and resistance to environmental stress conditions. Based on the latest investigations and the four different chickpea breeding categories, namely, drought resistance, productivity, seed size, and quality, the following genotypes have been prominent category-wise for developing new genotypes with desirable traits. For drought resistance, on average, the genotypes are F88-85C, F07-80, F10-206C, F97-30, F02-70, F97-147, F02-70, F97-24, F07-39, F97-126, 3312, D84-14, D-8807, F06-76, 42141, F97-24, 12129, 31107, 23205, 31232, F06-37, 23225, D88-03, K-3570, and F10-206C, recommended for use in future breeding programs.

Table 3. Characteristics of chickpea genotypes' grain weight per plant and 1000-seed weight.

Chickpea genotypes	Seed weight plant^{-1} (g)	1000-seed weight (g)
Standart Kamila	33.2	290.0
F97-126	33.3	290.0
12106	34.1	250.0
23232	33.4	282.0
9487	43.0	210.0
12109	42.8	300.0
23216	32.5	270.0
14-Б	39.6	288.0
2814	40.2	260.0
F02-70	35.2	280.0
Vector	33.2	280.0
23210	41.2	280.0
23224	34.2	280.0
3018	33.6	290.0
K-3570	33.3	300.0
K-1783	31.2	326.0
D-8807	35.3	320.0
3333	30.2	365.2
12233	32.5	380.0
D84-14	30.5	384.0
K-1446	33.1	375.0
K-288	32.8	364.5
D84-09	32.4	385.0
F88-85C	33.1	382.2

Chickpea pods - 2023

Chickpea plant height - 2023

Figure 1. Chickpea bundle F98-50c.

For higher productivity based on the seed weight per plant (>33.2 to 43.0 g) the following genotypes, i.e., 3312, K-3238, F97-126, 1457, 12227, 12106, 23232, 9487, 12109, 23216, 14-B, 2814, F02-70, Vector, 23210, 23224, 27-B, F07-80, Sharik, Krasnakutsky-36, K-1221, D-8420, 3018, 12233, 3050, K-3214, Zolotoy-Yubley, K-2801, F93-93C, F82-150C, 31105, D84-19, D84-14, 12126, 23209, and K-1783, have reached recommendations for future use. Based on the seed size and 1000-seed weight (>290-385 g) and exceeding the standard genotypes, the genotypes, 3018, K-3570, K-1783, D-8807, 3333, K-1221, 12233, D84-14, K-1446, K-288, D84-09, F88-85C, 14-B, F05-90, F06-76, 482, K-1783, K-3214, 23211, K-130, 12222, F10-86C, 3411, F14-46, K-32213, F10-206C, 482, 12228, 42145, 31232, 31108, 31105, 12119, 12108, 12125, 3046, 12118, 42134, 12227, 12216, and 31107, gained endorsement. For higher seed protein content (>28.0%), the chickpea genotypes, i.e., K-574, K-612, 2956, 2105, Miras 07, Nurly-80, K-1221, 482, 510, K-2197, and F98-50c, proved beneficial for use in future breeding programs.

CONCLUSIONS

According to the pertinent investigations and the four imperative breeding categories, i.e., drought resistant, productivity, seed size, and quality, the chickpea (*C. arietinum* L.) genotypes have been notable for use as parental pairs in the future conventional hybridization program for developing new genotypes with desirable traits.

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