

Name of the research and technical program: BR10765056 «Creation of highly productive varieties and hybrids of grain crops based on the achievements of biotechnology, genetics, physiology, biochemistry of plants for their sustainable production in various soil and climatic zones of Kazakhstan»

Relevance:

Kazakhstan is an agricultural country where grain production plays an important role for both local consumption and exports. The major production of wheat and barley in the country is concentrated in the northern regions. Grain crops breeding (wheat, barley, rice, maize, etc.) is traditionally carried out using classical methods. The development of biotechnology, genomics, molecular genetics, IT technologies, and bioinformatics makes it possible to accelerate and improve the breeding process. The proposed program is aimed at the creation of competitive grain crops cultivars (wheat, barley, oats, maize, rice, etc.) in accordance with strategic objectives to improve the country's food security, provide livestock and processing industries, and for the export. For this, integrated interdisciplinary scientific research of agronomists, breeders, phytopathologists, biochemists, geneticists will be carried out with the involvement of modern methods and approaches. Dissemination and implementation of the program's results will increase the social and practical significance of agricultural science. There is a corresponding background: 1) a Consortium of breeders, geneticists, phytopathologists, etc., representing 10 teams participating in the agrarian, academic and university spheres of science, foreign consultants has been created; 2) collections of grain crops have been formed; the challenges and main directions of breeding were discussed together with the need to create a cultivar model; experience in breeding, seed production, phytopathological, biochemical, molecular genetic work (DNA genotyping, GWAS, development of KASP markers, etc.). Fulfillment of the Program's goal and objectives will help to create competitive grain crops cultivars, considering the relevant natural and climatic conditions. It will involve the developed cultivar models, modern methods of molecular selection, and biotechnology. Significance and social effect are 1) the transfer of advanced technologies, obtaining new knowledge in the field of breeding and agrobiotechnology; their application to accelerate and increase the efficiency of grain breeding, 2) addition and update of the grains range and maintenance of the grain export potential; 3) the dissemination of knowledge, strengthening the prestige of agricultural science in society; 4) participation of young scientists, undergraduates + doctoral students, training, internships, interaction of specialists from the Ministry of Education and Science and the Ministry of Agriculture, farmers, etc. The program has a great significance on both national and international levels. Scientific products will be represented on the web page of NJSC "S. Seifullin KazATU" and distributed via "KATU Extension Office".

The goal of the program: Increasing the productivity of the agro-industrial complex of the Republic of Kazakhstan through the creation and accelerated introduction of highly productive and resistant to stress environmental factors of varieties and hybrids of grain crops of a new generation using the world plant diversity, methods of classical breeding, molecular biology and bioengineering.

Expected results:

On the basis of biotechnological and biochemical methods, new drought-resistant varieties of spring and winter soft wheat, spring durum wheat and triticale will be created for various regions of Kazakhstan:

- in the corresponding stages of the breeding process 30150 wheat breeding numbers will be studied annually: winter soft wheat - 12250, winter and spring durum wheat - 5500, spring soft wheat 12000, triticale 400 (winter and spring);

- intraspecific, interspecific and interspecific crosses will be carried out (topcross, backcross, saturating crosses) in the amount of 510 combinations of crosses (annually 170 combinations of crosses); targeted hybrid wheat populations will be obtained; biochemical control of varietal uniformity and typicality in nurseries PV1 (4500 ears of 3 varieties) and

PV2 (900 families of 3 varieties) of winter soft wheat will be carried out;

- rapid homozygotization of selected promising wheat and triticale lines will be carried out using androgenetic methods: culture of anthers and isolated microspores *in vitro*; the obtained dihaploid lines will be tested for productivity, rust resistance and evaluated according to grain quality indicators; dihaploid lines will be identified using DNA markers for economically valuable traits; the mineral and biochemical composition of grain of synthetic forms of wheat, dihaploid lines of wheat, barley, oats will be investigated, in connection with the level of productivity, sources of stable quality will be identified;

- the role of Zn in drought resistance of spring wheat plants will be identified.

- the following will be transferred to the RSE "State Commission for Variety Testing of Agricultural Crops" of the MA RK (hereinafter - GKSISK): 3 varieties of spring soft wheat (including 2 varieties of intensive and semi-intensive type); 1 variety of winter soft wheat; 1 grade of durum wheat and 1 grade of triticale; a preliminary conclusion of GKSISK will be obtained on morphological characteristics for novelty and distinctness (after filing an application for variety testing).

A new variety of spring wheat for the northern regions of Kazakhstan will meet the following parameters:

- yield in production conditions not lower than 35 c / ha;

- grain quality: protein - 15%, gluten - 27-30%;

- resistance to lodging - good at least 4 points;

- resistance to major diseases and pests - good at least 4;

- drought resistance - good at least 4;

- will be published: 22 scientific papers in editions recommended by CCSES, and abstracts in journals, at international conferences, incl. 2 - with a non-zero impact factor, 1 recommendation will be developed, 2 patent applications of the Republic of Kazakhstan will be filed;

- 1500-1800 tons (annually 500-600 tons) of high quality original and elite wheat seeds will be produced; new varieties of wheat will be introduced on an area of 800-900 hectares;

- students and young specialists will be involved in the work, incl. 2 undergraduates and 1 doctoral student.

For various regions of Kazakhstan, innovative varieties of winter and spring barley, spring oats will be created in terms of productivity and grain quality, surpassing domestic and foreign analogues:

- in the respective stages of the selection process the following will be studied: 900 lines and numbers of winter barley, 18000 lines and numbers of spring barley, 9000 lines and numbers of summer oats;

- an assessment of resistance to diseases will be carried out on a natural background of 3000 numbers of winter and 6000 numbers of spring barley, 3000 numbers, on an artificial background of 20 numbers of winter crops, 25 numbers of spring barley and 15 numbers of oats;

- identification for allelic diversity of genes *Vrn* (*Vrn-H1*, *Vrn-H2*, *Vrn-H3*) and *Ppd*

(*Ppd-H1*, *Ppd-H2*) in 40-50 collection varieties of barley, used as a starting material;

- in order to establish the combination of *Vrn*, *Ppd* alleles and the directionality for specific cultivation conditions, identification of the allelic diversity of the *Vrn* and *Ppd* genes will be carried out in barley lines of older breeding nurseries (40-50 samples); an immunological assessment of the selection material of spring barley will be carried out - 300 samples;

- 1 variety of winter barley, 1 variety of spring barley and 1 variety of oats will be submitted to the GKSISK; 3 patent applications will be filed; a preliminary conclusion will be obtained from GKSISK on morphological characteristics for novelty and distinctness (after submitting an application for variety testing); 6 scientific articles will be published in

publications recommended by CCSES, and abstracts in international conferences, including 1 with a nonzero impact factor;

- seeds of the highest reproduction of winter, spring barley and oats in the amount of 90 tons will be produced; new varieties of barley and oats will be introduced on an area of 600 hectares.

Rice breeding: 90 combinations of complex-step distant crosses will be performed, 350- 360 thousand hybrid seeds will be obtained, 200-210 hybrid populations will be reproduced, 2900-3000 ancestral elites will be selected; 3000-3400 numbers will be analyzed in the breeding nursery; control - 225; competitive - 34-36; 700-750 lines will be evaluated for cereal properties of grain, abiotic resistance; 2 varieties of rice will be created; 2 patents will be received; licensing agreements will be concluded with subjects of seed and commercial rice production for intellectual property objects (varieties); recommendations for the creation and implementation of new competitive varieties will be developed, resource-saving, innovative technologies will be developed for cultivating rice and diversifying crops of rice crop rotation; 1 article published in Web of Science publications (at least Q 3) or Scopus percentile at least 30 (thirty), 3 articles in publications recommended by CCSES.

Breeding of corn and sorghum crops:

- the following will be transferred to GKSISK: 2 new corn hybrids - one with a high starch content in the grain; one early maturing, drought-resistant; 1 variety of sorghum for forage direction with a yield of green mass not lower than 900-1000 c / ha for 3 cuttings with sugar content in the juice of the stems more than 20%, 1 variety of Sudanese grass, characterized by drought resistance; a preliminary conclusion of GKSISK will be obtained on morphological characteristics for novelty and distinctness (after filing an application for variety testing); a recommendation will be developed for the varietal technology of cultivation of corn and sorghum crops;

- superelite of self-pollinated corn lines, sterility fixers, fertility restorers in the amount of 800 kg and parental forms - TT 2 tons, superelite of seeds of sorghum crops - 2 tons will be produced; 5 scientific articles and theses, including 1 with a non-zero impact factor in foreign scientific journals will be published; 4 applications for patents for breeding achievements will be submitted; young specialists and 1 undergraduate will be involved in the work.

Results of research obtained during implementation of the program in 2021.

As a result of primary analysis, a DNA passport of 60 varieties and promising lines of soft spring wheat was created using 10 informative KASP markers associated with economically valuable traits that determine adaptability and productivity of plants.

As a result of clustering the collection of soft wheat using 10 KASP markers, a dendrogram was created which shows that samples from three breeding organizations in Kazakhstan are related.

During the reporting period, three sets of wheat were characterized for juvenile resistance to common races of stem and leaf rust. At the same time, the first set consists of 42 new breeding varieties and lines of spring soft wheat obtained under the KASIB program, the second set consists of 15 durum spring samples from KASIB, and the third set - of 100 foreign lines of spring soft wheat, respectively. As a result of research, a collection was formed consisting of 11 new breeding lines of spring soft wheat and 1 variety of spring durum wheat resistant to common stem rust races, as well as 7 lines of spring soft wheat and 5 samples of spring durum wheat resistant to common leaf rust races. In addition, foreign lines of spring soft wheat, resistant and moderately resistant to the dominant races of pathogens *P.graminis* f.sp.*tritici* and *P.triticiana*, were identified.

In compliance with the plan, all organizations implementing the Program performed comprehensive (technological, immunological, biochemical, molecular genetic, biotechnological) assessment of lines resistant to biotic and abiotic environmental factors in breeding nurseries for production in their zones and in general.

Research and Production Centre of Grain Farming named after A.I. Barayev created a

new variety of spring soft wheat in memory of Kaskarbayev. An application for patent has been made.

1 variety of winter soft wheat with a yield of at least 35 centners per hectare, grain protein content of at least 14%, raw gluten content of at least 25%, and below -18 ° C frost resistance at the tillering node was transferred to the Karabalyk Agricultural Experimental Station for the state variety testing. 1 patent application was made.

Drawing upon the long-term data of competitive variety testing of winter sowing, a sample of winter soft wheat 6868H2 was transferred to the State variety testing under the name "Tanbaly" by the Krasnovodopadskaya Experimental Station.

Based on the analysis of experimental data obtained during the reporting period in 2021, 22 scientific papers were published, including 3 articles in journals included in the Scopus database, 11 conference reports and one recommendation were made.

Results of research obtained during implementation of the program in 2022.

Based on the analysis of experimental data obtained during the reporting period in 2022, 16 scientific papers were published, including 2 articles in journals included in the Web of Science database, 9 - in journals included in the list of the Committee for Quality Assurance in the Sphere of Education and 3 conference reports, 2 scientific articles in foreign journals (Appendix G).

As a result of research of the second year of the program, collections were added to the DNA-bank of the following: spring common wheat (47), durum wheat (12), rice (40), barley (52) received from the Barayev SPC, North-Kazakhstan Experimental Station, Karabalyk Experimental Station, Aktobe Experimental Station, Khristenko Karaganda Experimental Station and Kyzylorda NIIR.

115 samples of common wheat, 52 samples of barley and 22 samples of durum wheat obtained from five breeding NRIs of Kazakhstan (Barayev SPC, North-Kazakhstan Experimental Station, Karabalyk Experimental Station, Aktobe Experimental Station, Karaganda Experimental Station named after A.F. Khristenko) were genotyped, which was carried out using informative KASP markers that had been previously converted from SNP markers identified as a result of PGAA or QTL analysis. The allelic status of the barley collection was also determined using the KASP marker *ipbb_hv_149* associated with the *Vrn-H1* gene and *ipbb_hv_138* associated with the *Ppd-H1* gene.

PCR conditions were optimized for 10 rice microsatellite DNA markers. Genotyping of 60 rice samples was carried out using 10 SSR markers. The most polymorphic SSR markers have been identified that can be successfully used for DNA certification of rice varieties and lines. At the next stages of the study, these samples will be analyzed using KASP markers. The obtained results can be further used in marker selection.

In KATU named after Seifullin. According to the results of field tests in the dry steppe zone of Northern Kazakhstan in arid conditions in 2022, the backcrossing line *AzxK-191* stood out, with excess over the standard being +4.0 c/ha. According to the results of genotyping, the largest number of stem and leaf rust resistance genes was found in the *Az x K-5* backcross line.

Drought resistance donors were identified for three of the four primers W51, W48, W54, and W62SNP2 developed for the *TaDREB5*, *TaDr1B*, *TaDr1D* genes, while for the line 329/11 - for all four primers.

In breeding for resistance to stem "Sr" and leaf "Lr" rusts, along with Astana, Akmola 2, Tselinnaya Yubileynaya, Karaganda 31, Karaganda 22, Taimas varieties, resistance for 6 presented genes was shown by 23 lines of spring soft wheat.

In Barayev SPC, new source material with a set of economically valuable traits has been created. 120 combinations of crosses were made, including 50 for spring soft wheat and 30 for spring durum wheat, 20 for barley; 20 for oats. At all stages of the breeding process, 10250 samples were studied, including 3100 for spring soft wheat, 3060 for spring durum wheat, 2045 for barley; 2045 for oats. An immunological evaluation of 1305 samples was carried out: 1259

samples for brown, stem rust and septoria blight of wheat, 24 samples for hard smut of barley, 22 samples for loose smut of oats. Technological assessment was carried out - 140 samples of wheat, including 70 samples of soft wheat and 70 samples of durum wheat. Biochemical evaluation of 140 samples was carried out, including 50 samples for soft wheat, 50 samples for durum wheat, 20 samples for barley, and 20 samples for oats. A new variety of spring naked barley has been created (Appendix E). A patent application has been filed.

In the reporting year, 302 numbers of a hybrid nursery, 4800 breeding lines SP-1, and 690 lines SP-2 were studied on the basis of the "North-Kazakhstan Experimental Station". In the control, preliminary and competitive tests, respectively, 88, 56 and 24 lines were studied. 62 hybrid combinations have been obtained. According to the results of screening in the current year, 11 samples resistant to leaf rust (degree of damage 0-1%) were identified in senior breeding nurseries.

In Karaganda Experimental Station named after A.F. Khristenko at all stages of the breeding process, 15641 numbers of spring soft wheat were studied, original and elite seed production was carried out on 3667 hectares. New hybrid populations were obtained in the amount of 150 combinations of crosses, the seed set was 32.7%. For barley breeding for 2022, 13014 numbers were under study. New hybrid populations of barley were obtained in the amount of 95 crosses, with a grain setting of 26.9%. In the competitive test, the varieties of barley Medicum 1231 and Medicum 1399 stood out in terms of yield and structural elements, which significantly exceeded the standard by 1.7-1.6 q/ha. Area under varietal crops in 2022 in Karaganda Experimental Station was 924 hectares, of which 129.5 hectares were under Karaganda 5 and 554.5 hectares - under Karaganda 6; 361 tons of seeds were obtained; oats occupied an area of 240 hectares, and 137 tons of seeds were obtained. Varietal crops of wheat in Karaganda Experimental Station cover an area of 3,667 hectares, 2,222 tons of original and elite seeds were obtained. Varietal crops of spring barley cover an area of 684 ha, of which 129.5 ha - under Karaganda 5 and 554.5 ha - under Karaganda 6, Mirny oats is sown over 240 hectares, and 137 tons of seeds were obtained.

In the Karabalyk Experimental Station for the reporting period of the current year, 31376 variety samples were studied in the selection process of grain crops.

In hybrid nurseries of different generations, 420 populations of spring soft wheat, 200 winter soft wheat, 270 spring durum wheat and 600 spring barley populations were studied. From the composition of the F5 hybrid nursery, the selection of elite ears was carried out in the amount of: spring soft wheat - 20,000 ears; spring durum wheat - 10500; winter wheat - 5000; spring barley - 20,000 elite ears.

Studied on spring soft wheat; SP-1 - 11,000 lines, SP-2 - 450 lines, KP - 168 lines; KSI - 48 varieties and lines. For spring durum wheat; SP-1 - 8000 lines, SP-2 - 300 lines, KP - 120 lines; KSI - 40 varieties and lines. For winter soft wheat; SP-1 - 1500 lines, SP-2 - 195 lines, KP - 84 lines; KSI - 24 varieties and lines. For spring barley; SP-1 - 7000 lines; SP-2 - 300 lines, KP - 110 lines; KSI - 47 varieties and lines.

1 variety of spring soft wheat with a yield of at least 30 c/ha, a protein content of at least 14% in the grain, a crude gluten content of at least 26%, which are highly resistant to fungal diseases and environmental stress factors, was transferred to the GSI. 1 patent application will be filed.

1 variety of spring durum wheat with a yield of at least 30 c/ha, a protein content of at least 15.0% in the grain, a crude gluten content of at least 28.0%, a vitreousness of at least 85%, and a high resistance to fungal diseases and stress factors of the external environment, the quality of pasta is not lower than 4.7 points. 1 patent application will be filed.

In the breeding nurseries of the 2nd year of grain crops, as a result of a comprehensive assessment, it was identified: 106 lines for spring soft wheat; winter soft wheat 73 lines, durum wheat 41 lines; spring barley 57 lines.

More than 2000 samples of winter wheat (breeding lines, hybrid populations, numbers) were studied in the Kazakh Research Institute of Agriculture and Plant Growing according to the

full scheme of the selection process in the field. Intraspecific, interspecific and intergeneric hybridizations (topcrosses, backcrosses, saturating crosses) were carried out in the amount of 170 combinations of crosses and purposeful hybrid populations of wheat were obtained. An assessment and selection of 300 breeding lines for a complex of valuable traits (drought resistance, yield and productivity indicators) was carried out. Prepared for transfer to the State Commission for Variety Testing of Agricultural Crops (GSI RK) a new variety of rainfed winter wheat called "Dulati". A patent application for a selection achievement has been filed.

The breeding material of corn and sorghum was tested in the amount of 1000 numbers. The initial material in the amount of 50 numbers was studied and created for the selection of corn and sorghum.

The method of electrophoresis in the SDS Na system recommended by UPOV for testing the distinctness, uniformity and stability of soft wheat varieties was tested.

In the Kazakh Research Institute of Rice named after Zhakhaev:

– Breeding and seed production of rice:

The breeding process was carried out according to the full scheme, which included hybridization in 80 combinations (according to the plan - 30), obtaining 143200 hybrid seeds (according to the plan - 100000), studying 70 populations in a hybrid nursery (according to the plan - 70); 1457 numbers in the selection (according to the plan - 1200); 77(75) - in the control nurseries of the first and second years; 14 - in competitive variety trials.

– Breeding and seed production of barley:

According to the calendar plan, in 2022, 4155 lines and numbers were studied (according to the plan 3600), nurseries were formed and established in successive links of the breeding process: collection-350; hybrid-75; SP-1- 3500; SP-2-170; KP -35; KSI-25.

According to the results of a comprehensive assessment of economically valuable traits in the collection nursery, 60 accessions were identified for individual economically valuable traits and 35 highly productive varieties for a complex of traits.

30 hybrid combinations were made by the method of topcross crossings, about 4500 spikelets were castrated, 400 hybrid grains were obtained. 2500 pure lines were selected from 75 F2-F6 hybrid populations.

Promising number 164/99-4L in 2023 will be transferred to the SCIC of the Ministry of Agriculture of the Republic of Kazakhstan.

In Aktobe Experimental Station in 2022 collection samples, lines, hybrids of spring soft, durum wheat and other types of wheat in the amount of 29169 were studied (with a plan of 25043). The study was carried out according to the full scheme of the breeding process. In seed nurseries, 6450 families have been studied, breeding nurseries R-1 have been created on an area of 12 hectares, R-2 - on an area of 28 ha.

Disease resistance. During the reporting period, four sets of wheat were characterized by seedling resistance to common races of yellow leaf spot. At the same time, the first set consists of 35 new varieties and a line of spring soft wheat of the Kazakhstani selection of Karabalyk Experimental Station. The second set consists of 109 lines of spring soft wheat from CIMMYT; the third set of 18 varieties of spring durum wheat, and the fourth set of 45 varieties of spring soft wheat from the Kazakh-Siberian Wheat Improvement Network, respectively. Using molecular markers, the genetic basis of 64 varieties from Karabalyk Experimental Station, Aktobe Experimental Station and North Kazakhstan Experimental Station was characterized for resistance to leaf and stem rust. As a result, single genes L-10, L-13, L-16, L-19, L-34, L-39, Sr 24, and Sr2 were identified in the analyzed samples.

At the Seifullin Kazakh Agrotechnical University, an online seminar was held on the topic of "Starting innovative entrepreneurship with breeding achievements" on November 17, in order to popularize and promote the results of research and S&D activities, within the framework of the scientific and technical program BR10765056 "Creation of highly productive varieties and hybrids of grain crops based on the achievements of biotechnology, genetics, physiology, biochemistry of plants for their sustainable production in various soil and climatic zones of

Kazakhstan".

The seminar was attended by leading scientific organizations in the field of agriculture LLP "Barayev SPC", LLP "Kazakh Research Institute of Rice Growing named after. I.Zhakhaev", LLP "Kazakh Research Institute of Agriculture and Plant Growing", LLP "Karabalyk Agricultural Experimental Station" LLP "North Kazakhstan Agricultural Experimental Station" LLP "Aktobe Agricultural Experimental Station" LLP "Karaganda Agricultural Experimental Station named after A.F. .Khristenko" and others.

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List of publications and patents made within the framework of this research and technical program (links included):

1 Amalova, A., Abugalieva, S., Babkenov, A., Babkenova, S., & Turuspekov, Y. (2021). Genome-wide association study of yield components in spring wheat collection harvested under two water regimes in Northern Kazakhstan. **PeerJ** (IF - 3.369, Q2, процентиль 83), 9, e11857. <https://doi.org/10.7717/peerj.118573>

2 Kokhmetova A., Rsaliev S., Atishova M., Kumarbayeva M., Malysheva A.,

Keishilov Z., Zhanuzak D., Bolatbekova A. Evaluation of Wheat Germplasm for Resistance to Leaf Rust (*Puccinia triticina*) and Identification of the Sources of Lr Resistance Genes Using Molecular Markers // Plants 2021, 10, 1484. <https://doi.org/10.3390/plants10071484> (Impact Factor 3.935, CiteScore 2.2, Процентиль 56%).

3 Tajibayev D., Yusov V.S., Chudinov V.A., Mal'chikov P.N., Rozova M.A., Shamanin V.P., Shepelev S.S., Sharmag R., Tsygankov V.I., Morgounov A.I. Genotype by environment interactions for spring durum wheat in Kazakhstan and Russia//Ecological, genetics and genomics. <https://doi.org/10.1016/j.egg.2021.100099> (Q4; SJR = 0.386).

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