ANNOTATION

Thesis work of Tajibaev Daniyar Gadelzhanovich on the topic: “Evaluation of durum wheat of the KASIB network (Kazakhstan - Siberia) and identification of genes influencing economically valuable traits”, submitted for the degree of Doctor of Philosophy (Ph.D.) in the educational program 8D08101 Agronomy, breeding.

Relevance of the research topic

The continuous growth of the world's population increases the need for food. Currently, the African continent faces the worst hunger, and more than 50% of Asia's population also suffers from hunger. On the other hand, climate change is also worsening the situation, negatively affecting agricultural productivity. According to Nadeem, there is an urgent need to increase global food production to meet the future needs of a growing population.

Durum wheat is a traditional and highly valuable crop, widely grown in Kazakhstan, a country that is one of the largest grain exporters in Central Asia. Durum wheat was grown on an area of up to 3-4 million hectares at its peak in the late 1980s. Durum wheat area in Kazakhstan in 2020 was estimated at 750,000 hectares with the leading regions being North Kazakhstan (300,000 hectares), Kostanay (260,000 hectares) and Akmola (150,000 hectares). The annual production of durum wheat in Kazakhstan reaches up to 500 thousand tons of grain with exports of up to 385 thousand tons. The main region of durum wheat production is Northern and Western Kazakhstan. According to FAO statistics, wheat production in Kazakhstan is 1.3 tons per hectare per year. Due to the above, yield stability and wide adaptation are becoming increasingly important.

To obtain high, stable yields, it is necessary to use highly adapted varieties to local conditions. To do this, it is necessary to conduct environmental tests of varieties in different regions. Most varieties grown in Kazakhstan are tall growing, day length sensitive material with good drought tolerance and suitable baking quality. Tajibaev documented that genotype-environment interactions of Russian varieties are more widely adapted to different growing conditions, and also reported that modern breeding needs new approaches, such as phenomics and genomics, to improve the wheat program, since it is very important to study and understand genetic diversity wheat through pre-breeding research.

This includes gene pool studies, phenomics, genomics and breeding, as well as linking desired traits to new varieties. Combining the best traits of agronomic and physiological parameters using genotyping and phenotyping methods in breeding will increase the yield of varieties. In the book Wheat Physiology, Reynolds says that targeted research in certain regions will undoubtedly increase the yield of wheat, and it also describes making various physiological observations depending on the required parameter and region for improving wheat. High-throughput phenotyping makes it possible to study complex traits such as plant growth and yield. In turn, this technology

allows reducing research time and labor costs while obtaining high-throughput screenings.

Marker-assisted selection can be used to characterize germplasm, allowing breeders to develop new genetic variations and use them to select parental lines for further crosses. In plant breeding, successful crossbreeding requires tracking of locus and genome regions, using molecular and DNA markers. To date, a large number of genetic markers have been developed to study many new traits of crops. To search for the level of polymorphism, codominant DNA markers are needed, which are also highly reproducible and distributed throughout the genome, allowing the study of wheat DNA as described. Calendar et al developed a new marker system called the interprimer binding site (iPBS). Due to their general applicability, ease of use, and genotype resolution systems, retrotransposon DNA markers have found widespread use in numerous evolutionary and genetic studies. The iPBS-retrotransposon amplification methodology is very practical and contains a robust DNA detection technology that does not require prior sequence information.

In addition to molecular characterization, using iPBS retrotransposon markers, it is possible to study the phylogenetics and evolution of various crop plants. To the best of our knowledge, no studies have yet been carried out on KASIB material using iPBS retrotransposons, with the exception of those who used the KASIB-DW nursery and use iPBS retrotransposons in wheat breeding and biotechnology, convenient for use in varietal and intravarietal identification of wheat genotypes. This study aimed to assess the genetic diversity and population structure of durum wheat KASIB germplasm using iPBS retrotransposon markers.

The purpose of the thesis research:

The purpose of the research is to identify genes that influence the manifestation of economically valuable traits of durum wheat in the South-East (Almaty region) and the North (Akmola region) of Kazakhstan and to develop methods for their use in the breeding process using modern genomic approaches and accurate phenotyping.

Research objectives:

1. Study of the main economically valuable characteristics of a collection of more than 150 samples of spring durum wheat KASIB in two regions of Kazakhstan (Almaty region - KazRIAPG and Akmola region SRC GF named after A.I. Baraev). Identification of promising lines/varieties of spring durum wheat for further selection and introduction into production.

2. Phenotyping KASIB-DW using digital methods in the Akmola region. Study of a new promising method of highly efficient phenotyping using a camera and the possibility of its use in breeding.

3. Genotyping KASIB-TP using known functional iPBS retrotransposon population markers to determine genetic diversity and population structure of all samples in the collection according to testing in 2021 and 2022.

Research methods

The study of the adaptive potential of durum wheat and the identification of high-yielding lines were carried out using classical breeding methods. Wheat samples were studied in two different regions of Kazakhstan, Almaty and Akmola regions. A total of 151 accessions of spring durum wheat were used, with seeding in randomized complete blocks and phenological observations including various growth and yield parameters.

In addition to classical methods, modern digital technologies were used for phenotyping with digital photographs and image analysis. Experiments with digital technologies were carried out in the Akmola region, where photographs were collected using special tools and image processing for analysis to eliminate distortions.

This dissertation also included extensive research into the genetic structure of durum wheat using iPBS retrotransposon genetic markers. These studies included DNA extraction, PCR, gel electrophoresis and bioinformatics methods for data analysis, allowing for more detailed study of genomic structure and identification of useful genetic markers for breeding and improvement of wheat as a crop.

Main provisions submitted for defense:

- adaptability of lines and varieties to two regions of the country.
- application of modern digital phenotyping methods.
- use of iPBS retrotransposon genetic markers to determine the genetic population of spring durum wheat

Description of the main results of the study

This dissertation presents a study of varieties and lines of spring durum wheat in the Almaty and Akmola regions of Kazakhstan. The results of this study confirm the influence of the length of the growing season on the agronomic characteristics of plants, especially in the context of yield losses and grain quality in the Akmola region. However, the results also highlight the adaptability of Russian genotypes, especially from Omsk, to various growing conditions, but the need to optimize the length of the growing season and sowing dates remains relevant.

Digital technologies, including digital photography, reveal potential for studying the growth and development of spring durum wheat varieties, and this may improve understanding of plant adaptive characteristics. This study also raises an important question about plant leaf area and its effect on photosynthesis and yield, which may be useful for breeding using the GA m2 and GGA m2 indices.

A genetic study of the KASIB durum wheat population using PCA, AMOVA and genetic distance methods confirms the high genetic diversity and the importance of iPBS retrotransposon markers for assessing genetic variation. These results highlight the importance of genetic diversity for the development of productive durum wheat varieties and highlight the importance of planning breeding programs in different regions.

The findings from this research contribute valuable insights into the cultivation and genetic diversity of durum wheat in Kazakhstan. It underscores the significance of considering regional variations in breeding programs and utilizing digital technologies for a more in-depth understanding of plant characteristics and adaptability. The continued exploration of genetic diversity and markers is crucial for the development of high-yielding durum wheat varieties, especially in the context of evolving agricultural challenges and changing environmental conditions.

Justification of the novelty and practical significance of the results obtained

For the first time, genotyping and phenotyping of durum wheat varieties and lines of the Kazakhstan-Siberian Spring Wheat Improvement Network is being carried out.

Selected high-yielding lines and varieties in the Almaty and Akmola regions from the KASIB nursery will be recommended for transfer to state variety testing.

The results of digital technologies will be recommended for implementation in plant breeding.

iPBS results of retrotransposons will be used to determine genetic diversity, population structure and geographic distribution of genotypes, and effects on agronomic traits will be identified. The use of functional and new markers in the selection of breeding material will significantly increase the efficiency of selection.

The practical significance of the dissertation lies in the selected high-yielding and highly adaptive lines/varieties for two regions of Almaty and Akmola regions. With the best growing season, with the best productivity.

The identified genetic populations are of great importance in durum wheat breeding.

These studies contribute to the transfer of varieties to the GSI by the originators of the varieties.

Compliance with areas of scientific development or government programs

The research carried out is a continuation of the Kazakhstan-Siberian network project, which began in 2000 and continues to the present day.

Description of the doctoral student's contribution to the preparation of each publication

During the dissertation work, the doctoral student took personal part in developing the research program and methodology, setting up and conducting laboratory and field experiments, and mastered the research methodology. He personally achieved certain results using selected research methods, systematized and analyzed the data obtained, and selected the right solutions to the tasks.

The doctoral student took an active part in discussing research results, preparing and justifying findings and conclusions on the topic of the dissertation, in preparing, designing and presenting them for publication in domestic and foreign publications.

Based on the results of research work, the doctoral student published 3 scientific papers, including 2 articles in scientific journals included in the international database of the Scopus information and abstract fund; 1 article in the proceedings of international scientific conferences and 2 recommendations.

Scope and structure of the dissertation

The dissertation is written on 101 pages, consists of an introduction, literature review, choice of research direction, research conditions, research results, conclusions, contains 13 tables, 21 figures, 11 appendices. The list of sources used includes 148 items.