

ABSTRACT

of the PhD thesis by DubekovaSaltanat Bakytzhanovna on the topic: "The immunological basis of the creation of sources of winter wheat material for selection for resistance to yellow rust " submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D08104 – «Plant Protection and Quarantine»

Relevance of the research topic. Grain production is an important strategic resource for Kazakhstan, a basic branch of agricultural production. The republic produces grain not only to meet the country's domestic needs, but also for export abroad. In the southern and southeastern regions of Kazakhstan, winter wheat is the dominant crop in the structure of grain crops. The deterioration of the phytosanitary condition of crops is closely linked to the introduction of short crop rotations, minimal soil tillage, and the cultivation of disease-susceptible, genetically uniform varieties. As a result, epiphytoses of crop diseases are becoming significantly more frequent. One of the most harmful diseases of winter wheat in southern and southeastern Kazakhstan is yellow rust caused by the fungus *Puccinia striiformis* f. sp. *tritici*. The pathogen affects the above-ground parts of the plant, which, depending on the dynamics of infection development and the susceptibility of the variety, leads to a decrease in the photosynthetic activity of vegetative organs, a decrease in seed quality and yield.

The high potential of the pathogen to produce new aggressive races makes most wheat varieties vulnerable to the phytopathogen. Ongoing global changes in climatic factors lead to the risk of the emergence of new, mutated pathogen pathotypes adapted to changing environmental conditions. Spores of the pathogen are rapidly spread over long distances by wind, airborne droplets. The risk of the emergence and spread of new virulent races of the pathogen, which can cause epiphytosis in wheat-growing countries, is significant. Thus, in recent years, aggressive races of the yellow rust pathogen have been found in Europe, Africa and Central Asia.

The pathogen *Puccinia striiformis* has caused epiphytotypic losses in many countries due to the loss of resistance genes Yr9 and Yr27. Thus, in recent years, yellow rust epidemics have been observed on several continents. The strategy of using pesticides is unpromising and leads to an increase in the rate of formation of genetic variability in the pathogen. The strategy of combating the pathogen is based on integrated plant protection, the main component of which is the widespread use of resistant varieties along with chemical control methods. Thus, in the southeast of Kazakhstan, the study of winter wheat varieties of local selection and world collections for resistance to yellow rust (*Puccinia striiformis* f. sp. *tritici*) plays an important role.

Research work is aimed at creating a breeding starting material resistant to yellow rust. Increasing the immunological potential of crops reduces the pesticide load on the agrocenosis, which makes it economically, environmentally and socially beneficial. In addition, regular systematic study of local selection and

world collections for resistance to pathogenic populations becomes a prerequisite for the correct selection of starting material for breeding. In this regard, the study of the resistance of winter wheat to yellow rust remains relevant and is a valuable scientific work for immunity-oriented winter wheat breeding.

The purpose of dissertation research.

To create starting material for winter wheat breeding, resistant to yellow rust.

Research objectives.

- 1) Immunological assessment of winter wheat collection and selection material;
- 2) Determination of the efficiency of *Yr* genes, search for sources of resistance to yellow rust;
- 3) Study of the structure of the yellow rust (*Puccinia striiformis* f. sp. *tritici*) population, determination of the racial composition of *Pst* in the southeast of Kazakhstan and the dynamics of their virulence;
- 4) Use of potential genotypes in selection according to immunological parameters, study of resistance of hybrid lines to yellow rust, DNA genotyping;
- 5) Structural analysis of the productivity of the winter wheat material, identification of high-yielding varieties with yellow rust resistance;
- 6) Selection of genotypes with valuable immunological characteristics and formation of yellow rust-resistant winter wheat starting material in the conditions of the southeast of Kazakhstan;
- 7) Purposeful transfer of immunologically valuable, yellow rust-resistant winter wheat lines as starting material for selection.

Materials and methods of research. Research material: varieties, lines and hybrids of winter wheat (*Triticum*). Object of study: causative agent of the disease – yellow rust (*Puccinia striiformis* f. sp. *tritici*).

Research method. From a methodological point of view, the scientific work includes traditional phytopathological, selection methods for studying plant immunity and is supplemented by the use of DNA molecular markers.

The main provisions for defense:

- 1) Immunological characteristics of winter wheat collection (Central Asia: Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan; Russia, Turkey and material from the international organization CIMMYT) and selection material were obtained;
- 2) The efficiency of *Yr* genes, which are sources of resistance to yellow rust, was determined, within the framework of the use of the International Yellow Rust Nursery (IYRTN) and the International Yellow Rust Differentiator Nursery (YR-DIF SET);
- 3) The structure of the yellow rust (*Puccinia striiformis* f. sp. *tritici*) population was studied, the racial composition of the dominant *Pst* in southeastern Kazakhstan and the dynamics of their virulence were determined;
- 4) The hybrid population of winter wheat, obtained by crossing with sources of *Yr* resistance, was genotyped using DNA molecular markers;

5) The yield indicators of the winter wheat material under study were analyzed, and high-yielding genotypes with resistance to yellow rust were identified;

6) Genotypes with valuable immunological characteristics were selected and a new block of starting material for the selection of winter wheat, resistant to yellow rust in the conditions of southeastern Kazakhstan was formed;

7) Immunologically valuable winter wheat lines resistant to yellow rust were purposefully submitted as starting material for selection.

Description of the main results of the study. Immunological characteristics of collection (Central Asia: Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan; Russia, Turkey, as well as material from the international organization CIMMYT) and breeding material (nursery of competitive variety testing) of winter wheat were obtained. In total, 68 genotypes (20%) of the studied collection and breeding material showed resistance, the remaining samples were characterized by susceptibility. A nursery of new source material of winter wheat for breeding was formed: a collection - 51 genotypes and a hybrid - 17 lines. A valuable database containing immunological characteristics of the studied genotypes was created. The efficiency of Yr genes, which are sources of resistance to yellow rust, was determined. Within the framework of the International Yellow Rust Network (IYRTN) and the International Yellow Rust Differentiator Network (YR-DIF SET), an evaluation of Yr isogenic lines/differentiators was conducted in nurseries to determine the gene efficiency on the yellow rust population in the region. The efficiency of the Yr5, Yr10, Yr15 and YrSp genes was determined. The population structure of yellow rust (*Puccinia striiformis* f. sp. *tritici*) was studied, the racial composition of Pst in the south-eastern region of Kazakhstan and the dynamics of their virulence were determined. The studied population of the yellow rust pathogen (*Puccinia striiformis* f. sp. *tritici*) is characterized by intrapopulation diversity. The main dominant pathotypes of the Pst population in Kazakhstan were: 31E158; 7E159. Frequent changes in the type of resistance of varieties during the years of study indicate an intensive gene flow of the Pst population in this region.

A new hybrid population of winter wheat obtained by hybridization with Yr resistance sources was genotyped using molecular DNA markers. The results of immunological assessment in the field and genotyping of samples using PCR analysis in the laboratory revealed the presence of effective resistance genes in our hybrid lines. Genotyping using molecular DNA markers confirmed that the obtained hybrid lines contain effective Yr10, Yr15 and Yr18 genes.

The yield indicators of the studied winter wheat material were analyzed and high-yielding genotypes with resistance to yellow rust were isolated.

Genotypes with valuable immunological characteristics were selected and a new nursery of source material for breeding winter wheat resistant to yellow rust in the conditions of southeastern Kazakhstan was formed. As a result of scientific research, new hybrid lines of winter wheat with immunological value, resistant to yellow rust, were obtained, confirmed by the Acceptance Certificate and purposefully transferred to the breeding department as source material and to the

gene pool department of the Kazakh Research Institute of Plant Protection and Reproduction to expand the genetic diversity of grain crops.

Justification of the novelty and importance of the results obtained. The scientific novelty of the research is the creation of new winter wheat hybrids resistant to yellow rust, the identification and selection of valuable genotypes and the formation of promising starting material for immunity-oriented breeding.

In the context of global changes in climatic factors in recent years, which lead to the threat of the emergence of new, mutated pathotypes adapted to environmental changes, it is important to study the resistance of genotypes to yellow rust (*Puccinia striiformis* f. sp. *tritici*) populations. New sources and donors of resistance, which are of fundamental and applied importance in expanding the new genotypic diversity of wheat breeding, were selected. As a result of the conducted research, the necessary information for breeding was obtained on the immunological potential of winter wheat genotypes, their resistance to the disease. The reaction of the population of yellow rust (*Puccinia striiformis* f. sp. *tritici*) was analyzed in recent changing climatic conditions. The effectiveness of Yr genes as sources of resistance to yellow rust was determined. A new valuable nursery of winter wheat hybrids was formed by crossing with isogenic lines, to expand the genetic diversity of wheat. Selected perspective lines of winter wheat resistant to yellow rust were purposefully transferred to the agricultural crops Gene Pool and Breeding Department of the Research Institute as starting material for breeding.

Relevance to scientific development directions or state programs. The dissertation work was carried out in 2021-2024 at the Kazakh National Agrarian Research University within the framework of the educational program for grant training of doctoral students in the specialty 8D08104 - "Plant Protection and Quarantine". Research work was carried out on the basis of the Laboratory of Immunity and Plant Protection of the Kazakh Research Institute of Agriculture and Plant Growing, within the framework of the state order for the implementation of a scientific and (or) scientific and technical project, under the budget program: BR10765017 "Research and ensuring the preservation, replenishment, reproduction and effective use of genetic resources of agricultural plants to ensure the selection process", project: "Creation of a comprehensive system for the development of the gene pool of agricultural crops as a fundamental factor of selection to increase the adaptability, stability and productivity of plant breeding in the agro-industrial complex of Kazakhstan".

Description of the doctoral student's contribution to the preparation of each publication. Based on the materials of the dissertation, 13 scientific works were published, including 3 - in peer-reviewed scientific publications indexed in the Scopus database; 5 - in scientific journals recommended by the Ministry of Science and Higher Education of the Republic of Kazakhstan, the Control Committee in the field of science and higher education; 4 articles in the International Scientific and Practical Conference and 1 Catalog of resistant wheat varieties (methodological recommendations). The publications reflect all the main scientific results of the research.

As a result of the author's scientific research, valuable source material for breeding was formed on the resistance to yellow rust (*Puccinia striiformis* f. sp. *tritici*). The dissertation is the result of the author's personal research in 2021-2024. The author participated in all stages of the work, was responsible for formulating the problem, setting goals and objectives, planning and conducting experiments, interpreting the data obtained, and publishing the results. The scientifically sound data obtained by the author on the resistance of breeding lines and collection genotypes of winter wheat are a big step towards the development of new genetically protected varieties in the future and their rational placement. The main results of the research were presented at international conferences:

- 2022-2023. A report was presented on behalf of Kazakhstan: "*Status of wheat rusts and the work on their management in Kazakhstan*". As part of the International seminar: "Training Workshop in cereal rust surveillance, race analysis, and management of wheat rust diseases in Central Asia and Caucasus". Turkey - ICARDA. Regional Cereal Rust Research Center (RCRRC).

- In 2024, a report was presented on behalf of Kazakhstan: "*Plant health system and emerging plant pest and disease of Kazakhstan*". International seminar: "Subregional Workshop on Development of Plant Health Priorities and Strategies in Central Asia and the Caucasus (CAC+) Region". Ankara, Turkey.

- In 2024, participated in the professional program "Biological diversity and identification of plant pathogens" on the basis of the "All-Russian Scientific Research Institute of Plant Protection", confirmed by passport No. 782417863854 (St. Petersburg, Russia).

- In 2022, at the International Young Scientists Project, the 1st degree diploma and medal (ID No.052) on scientific work were awarded "Best Scientist - 2022 Commonwealth of Independent States". Topic: "Resistance of genotypes of winter wheat, to Kazakhstan population of yellow rust (*Puccinia striiformis* f. sp. *tritici*)". VI International Book Edition of the Commonwealth of Independent States "The Best Young Scholar - 2022" Volume IX. Astana, 2022.

Scope and structure of the dissertation. The dissertation consists of an introduction and the main part, which includes: an analytical review of the literature, a description of the methodology, a description of the experiments and research results presented in 6 sections, a conclusion, a list of references and appendices; there are Acts of submission of the source material for Selection. The work is presented on 129 pages, consists of 17 tables and 23 figures. The list of references contains 223 sources, including 206 foreign references.

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