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Assessing Kazakhstani wheat varieties by yield indicators and resistance to rust

Abstract. According to the experts of the Food and Agriculture Organization (FAO), the annual global loss of products from diseases and pests of agricultural crops in 1986-1990 was 52.2 million from 1998-2005 from a conventional unit of grain to 70 million tons. One of the factors that reduce the yield indicators of grain crops, contributing to a sharp decrease in yield, is the rust disease, which causes damage to grain crops, except for wheat Aegilops, Elymus, Agropyron, etc. The problem of contamination of grain crops with phytopathogenic fungi is quite a serious problem for the countries of Central Asia, since, according to FAO, this region is characterized by a higher level of bread consumption per capita (about 200 kg per year), and agriculture is considered as one of the key factors of the economy. The cost of production is an economic factor and negatively affects the sustainable development of agricultural production. A comprehensive study of the source material obtained in breeding, the replacement of ineffective ones with effective ones, makes it possible to suppress the rate of development of the pathogen and prevent epiphytosis. The evolution of the adapted parasite is accompanied by the evolution of the host plant. The article examines the complex resistance of domestic and foreign wheat varieties to rust in an artificial epidemic environment. Over the years of research, a comparative analysis of the resistance of wheat varieties to diseases has been carried out. Field tolerance was noted in the varieties Almaly, Arap, Zhakut, Naz with 3-4 points, in the varieties Samar and Zhalyn with 2 points. As a result of the structural analysis of the yield of winter wheat varieties allowed for sowing in production and promising, a decrease in these indicators was found under the influence of the disease.

Key words: wheat, rust, resistance, yield index, phytopathogen.

Introduction

Wheat rust diseases the most common dangerous fungal diseases in cultivated fields are stem rust *(Puccinia graminis f.sp.tritici)*, yellow rust *(Puccinia striformis tritici)* and brown rust (*Puccinia recondita*). Although there is a slight difference in the development conditions of each of these diseases, all these diseases are widespread in all regions of Kazakhstan where wheat is sown. Often they can survive in the same field at different stages of wheat growth, as well as in different natural conditions.

The main problem for all states producing agricultural crops is to increase grain productivity and improve the technological quality of seeds [1]. In developed countries, rust diseases, especially brown and stem rust, are biological factors that inhibit the production of wheat, which is explained by the fact that new races of the pathogen appear quickly and spread to remote areas through the air flow. In the spring period, wild grain crops are considered sources of carriers and carriers of infection, as they begin to develop rust 7-10 days earlier than freshly sown wheat and winter wheat. This type of rust disease is primarily dangerous for winter and summer grain crops. From wild grain crops, yedet is infected with winter wheat,and from winter wheat-with spring wheat. The epidemic is spreading rapidly in wheat crops. In favorable weather conditions, the causative agent of rust is transmitted from wheat leaves to

leaves, spreading, and during the period of intensive development, it also affects the ear. That is, the plant is able to form several genera during all vegetative periods. The presence of high temperatures and low relative humidity during this period of time is a favorable environment for the generation of fungi and the formation of a large number of uredospores [2, 3].

In order to prevent the risk of epiphytosis, yellow and brown rust diseases, scientists from Kazakhstan, CIMMYT and ICARDA are working together [4-6]. In the Republic, brown rust is widely distributed, yellow rust is found in the mountainous regions of the South, East and South-East, and stem rust is found in the wooded and flat areas of the northern regions. Rust, which damages wheat, is distributed in 65% of the territory of Kazakhstan. Wheat-brown rust is more widely distributed in the forest-flat and flat regions of the North, West, and North-East of Kazakhstan. It is also found in West Kazakhstan, Aktobe, Pavlodar, East Kazakhstan, South Kazakhstan, Zhambyl and Almaty regions. In the conditions of Russia and Ukraine, rust diseases overwinter in the form of brown rust uredinomyceli, in warm weather in the winter months uredinospores are preserved in winter wheat, wild grain crops. As an intermediate host, *Thalictrum* and *Leptopyrum* species do not play a major role in the development of brown rust. However, it serves as a reserve for the emergence of new pathotypes (races) [7, 8].

Factors determining the degree of development of wheat brown rust are the influence of temperature (the growth limits of urediniospores are between 2 and 32°C with an optimal temperature of 15-20°C) and drip humidification for at least 4-6 hours. In case of favorable conditions, the causative agent of brown rust can reduce the yield of wheat by up to 45%, and in case of development of the disease in the phase of headache by 80-100%, the damage to grain can be 50% [9, 10]. The harm of rust leads to a deterioration in the assimilation function of the plant, a violation of physiological processes in them, and a decrease in the cold resistance of winter wheat. Under the influence of the disease, the process of synthesis and accumulation of starch and protein in the endosperm is inhibited, preventing the formation of gluten components in the grain [11-13]. The development of rust fungi directly depends on environmental factors. Among the abiotic factors that directly affect the development and spread of the pathogen, climatic factors are: temperature, humidity. As an example, one of the factors determining the level of development of brown rust, if we take temperature, humidity, the temperature required for the germination of uredinispora is from 2 to 32°C, with an optimum of 15-20°C and the presence of moisture in the form of drops for 4-6 hours. At the same time, the development of the fungal disease rust in acreage depends on the plant's resistance gene. Sowing genetically homogeneous varieties on acreage allows you to spread rust diseases, develop to the level of epiphytosis [14].

The resistance of varieties to diseases is an important element of plant protection against diseases, which stabilizes agricultural production, reduces the risk of environmental pollution. However, phytopathogenic organisms can quickly adapt to the plant's defense system. A particularly intensive evolutionary process takes place in populations of pathogenic rust fungi that live parasitized on agricultural crops and can be transported hundreds or thousands of kilometers by air flow. Resistance to brown rust, for example, in zoned varieties, does not exceed 5-6 years. However, the most effective and environmentally friendly strategy for plant protection is considered to be the selection of immunity to diseases caused by phytopathogenic fungi [15].

In the studies of E.D. Kovalenko [16] and V. P. Shamanin [17], the success of selection the production of stable, long-lasting varieties of resistance shows that this is due to genetic diversity, the presence of a favorable environment for the development of the disease, the composition of the epidemic background for the selection of varieties.

Newly created varieties in different countries of the world quickly lose their stability due to the emergence of new viral races of the pathogen. Therefore, the main direction of international selection of grain crops for immunity to diseases is the creation of long-term resistant varieties that maintain the effectiveness of resistance for at least 10 years in various agroecosystems, under favorable conditions for the development of the disease [18]. Long-term resistance selection includes the following stages: study of the variability of the population of pathogenic microorganisms, constant monitoring of the emergence of new, potentially dangerous pathotypes; development and selection of source material for sorting resistant varieties. Study of the variability of the population of pathogens, constant monitoring of the appearance of potentially dangerous races [19, 20].

To choose varieties of crops that are resistant to diseases, it is important to evaluate the source material and choose resistant forms. E. Geshele [21] proposed a scheme of the selection process, consisting of 4 stages. At the first stage, the source material, commercial and promising varieties are

studied and their targeted hybridization is carried out. At the second stage, disease-resistant forms are selected among hybrid plants. At the third stage, their resistance to major diseases is determined and the best forms selected are multiplied, at the fourth stage, the selected forms are tested on large areas of acreage. An effective way to combat a particularly dangerous wheat pathogen is to produce a new germoplasm of varieties, that is, wheat varieties that are immune to diseases and highly productive, which provide resistant genes, stop the decline in yield and improve the quality of grain. Possum-plant resistance, suppresses the spread of diseases and reduces the level of the pathogen population. Since the ability of the population composition of rust species to adapt to mutation is unlimited, the work on obtaining resistant varieties in breeding is a complex and continuous process. The use of genetically resistant wheat varieties in production is the most effective, economically and environmentally reliable approach to Disease Control, which reduces the use of fungicides.

Materials and methods

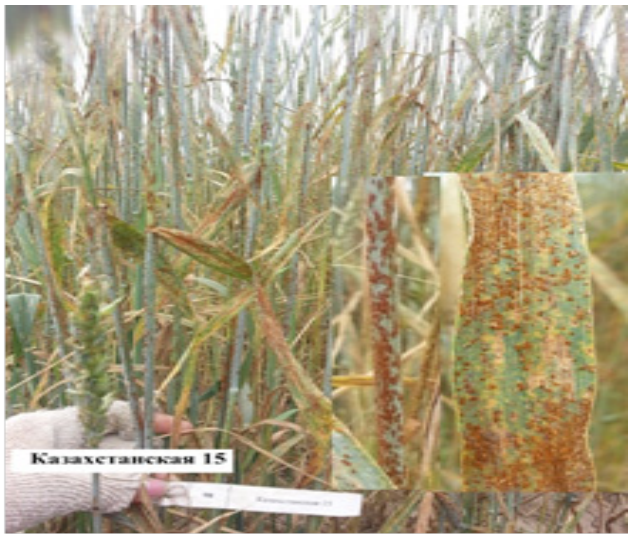
The research work was carried out on the irrigated field site of the Institute. In field conditions, each variety was sown with a grain seeding machine on areas with a width of 1 m, A length of 3 m, and manually sown in two or four rows of 65-80 grains on Transparent areas with a width of 1 m, a row of 20 cm. On one side of the seedling, control varieties were grafted as carriers of the disease. Phenological observations of plant growth were carried out according to J.G Zadoks, inoculation during rooting (stages 20-29). In order to create an infectious environment for wheat rust species and to take into account the development of the disease, spores were infected by spraying on plants. In order to create an infectious environment for plants, wheat varieties were infected by spraying with an aqueous solution of rust uredospores (infection rate 20 mg/m^2) at the stage of germination [22]. To ensure high humidity after infection, the experimental microdistricts were covered with plastic films and a wet chamber was created for 24 hours. When taking into account rust damage, the type of rust damage to the stem of plants on a five-point scale was conducted by E.C.Stakman, M.N.Levine [23], brown rust by E.E.Mains, H.S.Jackson [24], yellow rust by G.Gassner, W.Straib [25] from 0 to 4 points. The rate or level of disease development was determined on the Cobb scale [26].

Results and discussion

It is important to reliably evaluate the material selected in the selection work for rust resistance. Three principles must be observed for objective assessment of new varieties and selected anti-rust varieties, lines, firstly, the effective use of resistance genes, given the differences in the composition of the pathogen population in the field, and secondly, the pathogenesis of the parasite in contact with host plants. thirdly, it is necessary to determine the virulence of the pathogen in the laboratory and in the field. On the basis of this topical issue, the resistance of domestic and foreign varieties to stem, yellow and brown rust in the field under artificial conditions was studied. Immunological response of varieties to rust was assessed on a scale of 0 to 4 points.

In the study, varieties with a score of 0 were classified as immune, varieties damaged by 1-2 points were classified as resistant, varieties with a score of 3-4 were classified as intolerant. According to the rate of infection, the development of infection was considered weak within 5-20%, 21-30% – moderate, 31-60% – moderate, 61-80% – high and 80-100% – very high. Among the studied varieties, high resistance to rust was found in domestic Taza, Tungish varieties, foreign Mironovskaya 901, Koloyan and highly resistant to disease, Zhalyn, Egemen varieties were moderately resistant. This tolerance was also observed in the foreign Senatori Cappelli variety. Although the Tolkyn variety was weakly affected by yellow rust (2 points, 30 percent), the stem and brown rust were damaged by 4 points, 40-50 percent. Most of the domestic varieties suffered from rust disease with a score of 3-4 points, in the range of 20-80 percent (Figure 1, Table 1).

In the field conditions, the incidence of stem rust of domestic and foreign varieties studied was higher than that of yellow and brown rust species, up to 60-80 percent were affected in the reaction of the 4-point type. Several years of use of varieties in production led to the appearance of virulent forms, a decrease in the effectiveness of resistant genes. In northern Kazakhstan, crop yields decreased by more than 50 percent in 1967 due to the development of crop rust to the level of epiphytosis. After this year, there are no registered epiphytosis of this disease in the world, in the Republic. In 1999, the emergence of a new race of stem rust disease Ug99 with the content of TTKS, the spread of grain crops around the world caused significant damage to wheat production [27].



Kazakhstanskaya 15

Lutescens 32

Steklovydnaya 24

Zhetysu

Altyn masak

Zhalyn

Figure 1 – Evaluation of resistance of wheat varieties to rust in field conditions

Table 1 – Resistance to rust disease of domestic winter wheat varieties, which are allowed for sowing in production and have prospects

Name of the variety	Types of rust		
	stem rust	yellow rust	brown
	Type of damage, level, score /%		
Almaly	4/60	3/50	3/20
Name of the variety	Types of rust		
	stem rust	yellow rust	brown
Ak dan	4/50	3/50	3/40
Altyn masak	3/5	4/30	4/60
Aray	4/50	4/40	3/10
Arap	4/40	3/30	3/40
Arman	4/60	4/50	4/50
Basar	2/20	0	0
Bereke	4/50	3/60	3/40
Steklovydnaya 24	4/80	4/70	4/60
Derbes	3/50	3/60	3/20
Zhakut	4/60	3/20	3/40
Zhalyn	2/20	2/5	2/10
Zhetysu	0	0	0
Egemen	2/5	2/20	2/20
Kazakhstanskaya 15	4/80	4/50	4/40
Karlygash	3/40	3/5	3/20
Kok-byday	2/5	4/20	2/10
Krasnovodopadskaya 210	4/70	4/60	4/50
Koksu	4/60	4/20	3/40
Koloyan	0	0	0
Lutescens 32	4/70	4/60	4/50
Myronovskaya 901	0	0	0
Naz	4/60	4/50	4/50
Ramyn	3/60	3/50	3/40
Rausyn	4/40	4/30	4/40
Sapaly	4/50	4/40	4/50
Taza	0	0	0
Tungysh	0	0	0
Tolkyn	4/50	4/40	2/30
Salamoni	4/80	4/50	4/60
Serie 82	0	0	0
Sebou	0	0	1/5
Senatori Cappelli	2/10	2/5	2/40
Bogarnaya 56, control variety	4/80	4/60	4/70

In the year of the study, when comparing the varieties tested in an artificial epidemic environment with yellow and brown tats, there was a high intolerance to class Rust, and the contamination was predominant. this may be due to the presence of a named virulent race or pathotype in the population

of a type of disease, or a pathotype with a high virulence similar to TTKS by nomenclature index. That is, the Sr2 gene, which protects wheat varieties from stem rust in the field conditions of varieties, depends on the effectiveness of the adult resistance gene (APR-gene, adult plant resistance gene). In the field of phytoimmunity, three types of resistance to rust diseases of grain crops are considered: non-specific basic or basic resistance provided by receptor proteins localized in the plasma membrane, specific racial or racospecific resistance provided by intracellular immune response receptors, and non-specific resistance signs controlled by digital loci resistance. Soft wheat (*Triticum aestivum*) is characterized by all these types of endurance. the endurance of an adult plant is determined in a way that is not typical for the race [28]. Resistance of an adult plant, or field resistance, is transmitted polygenically to its offspring. Unlike sprout resistance, which has a monogenic resistance, rust fungus is effective for many sets of races. Resistance of an adult plant can manifest itself at every stage of development, sometimes before the stage of maturation. Varieties that are not characteristic of the race or have field resistance are in most cases intolerant during germination, but are more resistant to diseases in the case of an adult plant. This type of tolerance is called polygenic, semi-factor tolerance. In the case of epiphytoia, these plants are less susceptible to damage than intolerant varieties.

Varieties with field resistance can be affected by the pathogen at a higher or lower level, depending on their genetic characteristics or environmental conditions. To find out the field resistance of wheat varieties to rust diseases, the type of damage determined in points and the degree of spread of the epidemic, expressed as a percentage, were multiplied and divided by the number of days from inoculium infection to calculating the disease. For varieties with field resistance, the value of the resistance index should be 1.6 in case of damage with 4 or 3 points, and for other types-1.3. In our studies, field tolerance was observed in Almalinsky, Arap, Zhakut, Naz varieties affected by tat with a score of 3-4 points, in Derbes and Zhalyn varieties with a score of 2 points. Varieties of Ak dan, Altyn Masak, and Koksu were affected by the pathogen up to 4 points, up to 80 percent (Table 2).

Table 2 – Determination of the disease resistance index of domestic winter wheat varieties that are allowed and promising for sowing in production

Name of the variety	Type of damage, level, score /%	Tolerance index
Almaly	3/10	0.86
Ak dan	4/80	9.14
Altyn masak	4/80	9.10
Aray	4/40	4.57
Arap	3/10	0.86
Arman	4/40	4.57
Bereke	3/60	5.14
Derbes	2/20	1.14
Zhalyn	2/20	1.14
Zhakut	3/10	0.86
Zhetysu	0	0.0
Karlygash	4/20	2.28
Kok-byday	3/40	3.43
Koksu	4/80	9.14
Naz	4/10	1.14
Ramyn	4/50	5.71
Sapaly	4/20	2.29
Steklovydnaya 24	4/80	9.10
Taza	0	0.00
Name of the variety	Type of damage, level, score /%	Tolerance index
Bogarnaya 56, control variety	4/70	8.00
Average indicator	3,5/41,0	4.28

Field tolerance, consisting of the entire defense system, was found in the varieties Almaly, Arap, Zhakut, Naz, Derbes, Zhalyn, which are allowed for production and promising. The tolerance index of these varieties was in the range of 0.86-1.14. Field resistance is the ability of the plant to produce stable yields, inhibiting the excitatory epiphytosis. Therefore, the assessment of the disease resistance index of varieties is considered important in breeding in order to prevent crop losses. Field-tolerant varieties Almaly, Arap, Jakut, Naz, Derbes and Zhalyn varieties with field resistance are less susceptible to damage than intolerant varieties in the presence of epiphytosis of rust species. These varieties slow down the rate of inoculum formation and reduce crop losses. This type of tolerance is sometimes referred to as polygenic, semi-factor tolerance. This type of resistance to the disease is partially effective, long-lasting when there are several genes (from three to five.

The yield of winter wheat varieties that are allowed and promising for industrial sowing and the weight of 1000 grains were measured and the reduction of these indicators under the influence of the disease was studied. As a control variety, the Bogarnaya 56 variety was obtained, which has been zoned in Zhambyl, Almaty and South Kazakhstan regions since 1981.

The yield of the studied varieties was 16.44-33.66 c/ha, with a grain weight of 1000 40,5-52,0 g. In the disease-resistant varieties of Ak dan, Bereke, Kok-wheat, Koksu, Ramyn, the yield was 16,44-20,80, and the weight of 1000 grains was 41.42 g. These indicators were higher in Almaly (26.61 c/ha, 51.5 g), Egemen (26.68 c/ha, 47.0 g), Zhalyn (28.33 c/ha, 46.9 g), Naz (33.66 c/ha, 50.5 g), Taza (26.67 c/ha, 48.4 g) and Tungysh (36.11 c/ha, 50.0 g) varieties that showed resistance to diseases (Table 3).

Table 3 – The main yield indicators in the middle of the rust epidemic of varieties that are allowed and are promising for industrial sowing

Name of the variety	Key revenue indicators			
	Crop yield (c/ha)	Deviation from control	Weight of 1000 grains (g)	Deviation from control
Almaly	26.61±0.48	+3.65	51.5± 0.7	+8.0
Ak-dan	16.44±0.60	-6.52	41.0±0.9	-2.5
Bereke	18.17±0.55	-4.79	41.4±0.7	-2.1
Derbes	22.00± 0.40	-0.96	43.0±0.9	-0.5
Egemen	26.68±0.50	+3.32	47.0±0.8	+3.5
Zhalyn	28.33±0.45	+5.76	46.9±1.1	+3.4
Kok-byday	19.17±0.45	-3.79	42.0±0.9	-1.5
Koksu	19.02±0.60	-3.94	41.6±0.9	-1.9
Naz	33.66±0.70	+10.7	50.5±0.8	+7.0
Ramyn	20.80±0.65	-2.16	42.0±0.7	-1.5
Sapaly	26.35±0.60	+3.39	52.0±0.9	+8.5
Steklovydnaya 24	26.61±0.50	+3.65	48.0±0.7	+4.5
Taza	26.67±0.55	+3.71	48.4±0.9	+4.9
Tungysh	36.11±0.63	+13.15	50.0±0.8	+6.5
Bogarnaya 56, control variety	22.96±0.40	-	43.5±1.0	-
$EAEA_{095}$ (c/ha)	1.74	-	1.36	-
$EAEA_{095}$ (%)	5.59	-	2.95	-

Indicators of yield of winter wheat varieties that are allowed to be sown for production due to rust disease and promising: spike length, number of spikes, number of grains in spikes, weight loss. Decrease in yield due to the disease was observed in Ak-Dan, Bereke, Koksu, Ramin varieties with

3-4 points, 50-80%. In disease-resistant varieties, the length of the spike is 7.0-11.0 cm, the number of spikes is 16-20, the number of grains in the spike is 35-47, the grain weight is 1.36-1.91 g, and in the intolerant varieties the spike length is 6.1 -6.9 cm, the number of spikes was 14, 15 pieces, the number of grains was 28-30 pieces, the weight of the grain was in the range of 1.20-1.32 g (Table 4).

Table 4 – Spikes of rust-infected winter wheat varieties allowed for production as well as promising

Name of the variety	Rust development, scores/%	Ear indicators							
		Length		Number of ears		Number of grains		Grain mass	
		cm.	±	pieces	±	pieces	±	г	±
Almaly	4/10	8.0±1.0	+1.2	18±1	+1	40±4	+3	1.41±0.9	+0.06
Ak-dan	4/80	6.6±1.4	-0.2	14±2	-3	28±2	-9	1.20±0.10	-0.15
Bereke	3/60	6.1±1.0	-0.7	15±1	-2	31±2	-6	1.32±0.12	-0.03
Derbes	4/20	7.0±0.9	+0.2	16±1	-1	35±1	-2	1.36±0.8	+0.01
Egemen	2/20	10.2±1.7	+3.4	19±2	+2	40±2	+3	1.85±0.20	+0.50
Zhalyn	0	10.8±1.2	+3.0	19±1	+2	41±3	+4	1.87±0.13	+0.52
Kok-byday	3/40	6.6±1.0	-0.2	16±1	-1	35±3	-2	1.33±0.12	-0.02
Koksu	4/80	6.9±1.0	+0.1	15±1	-2	30±2	-7	1.30±0.7	-0.05
Naz	4/10	10.3±0.8	+3.5	19±1	+2	39±3	+2	1.59±0.18	+0.24
Ramyn	4/50	6.6±0.8	-0.2	15±1	-2	30±3	-7	1.32±0.8	-0.03
Sapaly	4/20	7.2±1.1	+0.4	18±2	+1	39±4	+1	1.58±0.10	+0.23
Steklovydnaya 24	4/50	8.1±1.0	-1.3	16±2	-1	30±3	-7	1.28±0.7	-0.07
Taza	0	8.2±1.0	-1.6	19±1	+2	45±3	+8	1.86±0.7	+0.51
Tungysh	0	11.0±0.9	+0.2	20±1	+3	47±3	+10	1.91±0.10	+0.56
Bogarnaya 56, control variety	4/70	6.8±1.1	-	17±1	-	37±2		1.35±0.10	-

Conclusion

According to foreign scientists, rust disease reduces the yield of wheat varieties, the quality of grain, reduces the length of ears, reduces the number of ears, the number of grains, and the weight of grains. Finally, in our studies, there was a decrease in yield, grain weight of 1000 grains and indicators of earwax (length of earwax, number of earwax, grain weight) in intolerant varieties of Ak-dan, Bereke, Kok-byday, Koksu and Ramyn varieties. The yield of these varieties was 2.16-6.52 c/ha less than the control Variety Bogarnaya 56, the weight of 1000 grains is 1.5-2.5 g, the length of the ears is 0.2-0.7 cm, the number of ears is 1-3 pieces, the number of ears is 2-9 pieces, the grain weight is 0.05-0.015 g. In order to avoid a decrease in crop yields due to diseases, it is possible to carry out by observing that these intolerant varieties are not sown in large quantities in production. Because several years of use of varieties in production led to the appearance of virulent forms, a decrease in the effectiveness of resistant genes.

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