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SEARCHING FOR RESISTANCE SOURCES TO WHEAT COMMON BUNT (Tilletia caries (DC.)

Abstract. Common bunt (Tilletia caries (DC.) the disease occurs in areas where autumn wheat is grown. In our country, most of the zoned wheat varieties are infected with this disease. Therefore, foreign germoplasm should look for sources of strength. In our research in the field of artificial epizootic environment, the Hungarian 21 varieties of soft wheat Tilletia caries (DC.) of the pathogen was made the phytopathological and genetic-selection analysis. The study revealed that 15 wheat varieties are resistant to diseases, of which 8 wheat varieties were highly resistant to diseases (IT-0). They are; Ati, Békés, Berény, Csillag, Futár, Pilis, Szala and Rege. We say 7 varieties that are resistant to common bunt (IT-1), they are Kalász, Mentor, Göncöl, Fény, Garaboly, Szemes and Vitorlás. The indicator of the biomass index (NDVI) was determined at the stages of vegetative development of plants in ears, flowering phase and milky stage. The average value of the biomass index is higher than 0.70, with a high score of 9 varieties that have Ati, Mentor, Hajnal, Göncöl, Tisza, Csillag, Futár, Garaboly and Szala. As a result of the analysis of structural characteristics, the varieties Körös, Mentor, Tisza, Szala, Szemes and Rege showed a high index for all characteristics. As a result, disease-resistant and high-performance varieties can be presented as common bunt resistant specimens in immune selection.

Keywords: wheat, pathogen, infection, samples, inoculation, common bunt, resistant.

Introduction. The main criterion for the food security of the state is the creation of highly productive and resistant wheat varieties. Annually cereals are sown about 15.5 million hectares in the Republic of Kazakhstan and about 17-18 million tons of grain are produced, of which about 8 million tons are exported to Europe, the Middle East and Arab countries. To ensure food security, it is necessary to increase genetic resistance to pests and diseases, as well as adaptation to climate change combined with improved agronomic practices [1, 2].

The use of genetically resistant cultivars is considered to be the most effective, economic and environmentally safe method for disease control. The region of Central Asia is one of the world's most important producers of wheat, encompassing a production are of more than 15 million ha [3-5]. The problem of ensuring crop stability is of particular importance for Kazakhstan, most of the grain-sowing regions of which are located in areas with insufficient moisture, high temperatures, excessive salinization and intense phytosanitary conditions [6-8]. Developing high yielding and leaf rust, stripe rust and stem rust resistant cultivars is an important objective of winter and spring wheat (*Triticum aestivum* L.) improvement programs in Central and West Asia [9-13]. Production of wheat in Kazakhstan is being constrained also by leaf spotting diseases, including tan spot, caused by *Pyrenophora tritici-repentis* [14-17] and common bunt, caused by *Tiletia caries* [18].

One of the most devastating diseases of wheat in the world is common bunt. The causative agents of the disease are the fungi Tilletia caries and T. Laevis [19, 20]. In Europe, the yield loss due to the common bunt was more than 50%, in some years this disease led to a complete loss of harvest [19, 21]. However, in

the first half of the 20th century, the common bunt caused more yield losses and quality, than all other wheat diseases in the United States of America [19]. The most important source of infection is contaminated seeds. Infection of wheat occurs during germination, this is promoted by cool and humid conditions. Affected ears of light weight, do not droop, have a greyish-violet hue, emit a herring smell [20]. Koyshybaev M.K. (2002) reported that when seed is sown with untreated seeds, wheat is affected by the bunt up to 10% or more, which leads not only to direct losses, but to a marked decrease in grain quality, and to the toxic properties of bile spores containing alkaloid trimethylamine, which adversely affects human health and agricultural animals. Strongly spore-contaminated seeds cannot be used for cooking food and animal feed [20, 22, 23]. Many Kazakhstan wheat varieties, which have a stable yield, high quality of grain and ecological plasticity, are greatly affected by the diseases on the infectious background. This can lead to large losses in the agrarian sector in the case of the emergence of epiphytotics [2].

In traditional agriculture, a common bunt is often exclusively controlled by chemical seed treatment. In modern conditions, when Kazakhstan began the process of entering the WTO, the export of wheat to the European Union must meet the requirements of organic farming. Considering that these chemical methods of treatment with seed disinfectants are prohibited in the EU and in accordance with organic certification standards, there is the need to use alternative methods of controlling a common bunt in organic conditions. However, since synthetic chemicals are banned in organic farming, the common bunt is a serious threat to the production of organic wheat and for seed production [24]. The Commission Regulation (EC) No 1452/2003 states that starting from 2004 all plant material used for organic farming should be produced without chemical treatments. Thanks to this decree, it now becomes extremely important that the seed and planting material are free of pathogens and of excellent quality [25].

In order to maintain high yield and excellent quality of seeds, organic producers must rely on disease-resistant wheat varieties [24]. The most effective method of combating the bunt is the genetic protection of plants, which is achieved by introducing new resistant to common bunt lines into production. Thus, instead of using chemical seed treatments, organic means are needed to combat plant diseases. Wheat varieties carrying resistance genes are used as an alternative method of fighting instead of chemical fungicides against common disease.

Materials and methods. The research work was carried out in the laboratory of genetics and selection of the Institute of plant biology and biotechnology and in the experimental field of the Kazakh research Institute of agriculture and crop production. The research study material consisted of from Hungary 21 varieties of soft wheat and common bunt Tilletia caries pathogen spores of crop in Almaty region acreage were used. In the study, Bogarnaya 56 was selected as a standard resistant to common bunt. In the inoculation of wheat with the pathogen A.I. Borggard-Anpilogova's method (1961) was used [26]. Samples Tilletia caries (D.C.) the V. I. Krivchenko scale (1974) was used to assess infection with the pathogen [27]. The V. I. Krivchenko scale (1974) samples Tilletia caries (D.C.) was used to assess infection with the pathogen [27]. According to this method: 0 - highly resistant varieties or entries, affection up to 1%; 1 - practically resistant, infestation of ears not more than 5%; 2 - moderately susceptible, no more than 10-25% of ears are affected; 3 - susceptible - 26-50% of ears; - highly susceptible - up to 51-100%. The method of determining the index of plant biomass (NDVI – Normalized Difference Vegetation Index) [28]. This method is used to calculate the indicators of the biomass index (NDVI) at the vegetative stages of wheat development. Methods for determining the productivity of wheat varieties. When the wheat was ripe, it was harvested and structural analysis was carried out. Statistical data processing was calculated in Excel [29].

Results. Previously, we studied samples of Bulgaria, SIMMYT, Bt-isogenic lines, and Romanian wheat on the common bunt disease [30-33]. PCR analysis revealed the sources of *Bt-9* and *Bt-10* endurance from the Romanian samples 02429GP-1, F08245G1, F08034G1 and F07270G2 identified. Of the isogenic lines, *Bt-0, Bt-1, Bt-2, Bt-3, Bt-4, Bt-5, Bt-6, Bt-7, Bt-9, Bt-10, Bt-11, Bt-14, Bt-15* and *Bt-8,9,10* are identified. From Bulgarian wheat varieties samples Karina, Enola, Iveta, Korona, Slaveya, Yunak, KM 135, Geya, Tsarevo and Boryana tilletia caries (D.C.) pathogenin highly resistant (IT-0), revealed that. Of the SIMMYT wheat samples, 10 wheat samples were found to be resistant to common bunt. 21 soft wheat from Hungary has been tested for disease resistance as part of an artificial epidemic. The study found common bunt of the samples (Tilletia caries (D.C.) Tul. & C. Tul) data were obtained on the persistence of field crops. In the period from the waxing period to the ripening period of wheat, the

incidence was estimated 3 times. Depending on the type of infection, models can be classified into 5 groups: highly resistant, persistent, weakly resistant, and moderately resistant (table 1, figure1).

Table 1- Disease resistance of common bunt of grain samples, Almaty region, 2019

Cultivar	Origin	Total No, of plants	Infection spikes, pcs				Infected plants, %	Disease reaction
			I-Infection	II-Infection	III-Infection	The total number of infected spikes		
Ati	HUN	105	0	0	0	0	0	R
Bekes	HUN	64	0	0	0	0	0	R
Bereny	HUN	88	0	0	0	0	0	R
Kalasz	HUN	78	5	1	0	6	7,7	MS
Koros	HUN	69	21	1	0	22	31,9	S
Mentor	HUN	91	0	5	2	7	7,7	MS
Hajnal	HUN	148	15	0	0	15	10,1	MS
Goncol	HUN	80	6	1	0	7	8,8	MS
Tisza	HUN	89	18	0	0	18	20,2	MS
Csillag	HUN	137	0	0	0	0	0	R
Futar	HUN	125	0	0	0	0	0	R
Feny	HUN	128	0	0	6	6	4,7	MR
Pilis	HUN	120	0	0	0	0	0	R
Petur	HUN	78	30	24	0	54	69,2	HS
Garaboly	HUN	85	0	3	0	3	3,5	MR
Szala	HUN	105	0	0	0	0	0	R
Szemes	HUN	148	0	2	0	2	1,4	MR
Vitorlas	HUN	102	4	4	0	8	7,8	MS
Rege	HUN	147	0	0	0	0	0	R
Raba	HUN	122	20	5	0	25	20,5	MS
Rozi	HUN	108	23	0	0	23	21,3	MS
Bogarnaya 56	KAZ	120	10	30	30	70	58,3	HS

Phytopathological assessment of resistance to common bunt was performed. The study of resistance to on an infectious background showed that 8 varieties are characterized by common bunt resistance to Tilletia caries with a incidence of 0%. These varieties include Ati, Vekes, Vegepu, Csillag, Futár, Pilis, Szala, Rege. Of the 21 samples studied, 3 are weakly susceptible (Fény, Szemes, Garaboly), and the affected ears do not exceed 1-5%. The group of weakly susceptible varieties with 6-25% included 8 varieties (Kalash, Mentor, Hajnal, Göncöl, Tisza, Vitorlas, Rose, Rose). The körös variety was shown to be susceptible (26-50% incidence). Varieties Petur and Bogarnaya 56 showed highly susceptible (51-100% incidence).

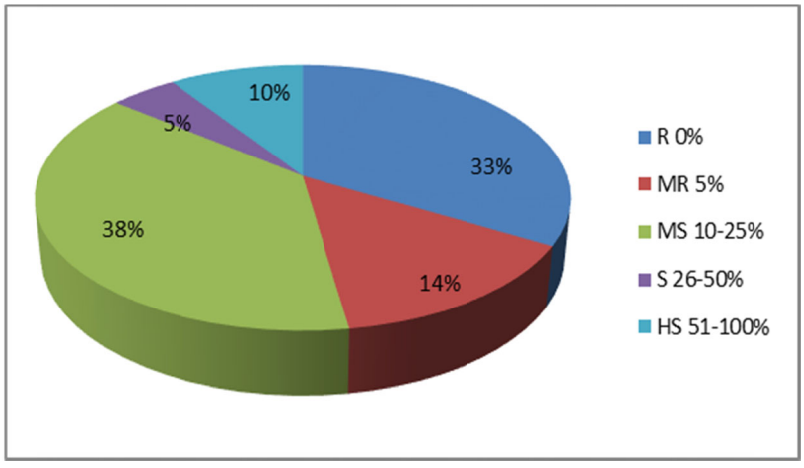

Figure 1 – Infection with the disease of common bunt of wheat varieties in the field of artificial infection, Almaty region, Almalybak 2019

According to the results of phytopathological screening, the studied 21 varieties of wheat are ranked according to the V. I. Krivchenko scale (1974) according to the degree of resistance to disease into groups: Resistant (33%), practically resistant (14%), moderately susceptible (38%), Susceptible (5%), Highly Susceptible (10%) (figure 1).

The biomass index (NDVI) was calculated during the vegetative development of wheat samples at the stages of colorfulness, flowering and molestation. During the ear period, the biomass index (NDVI) was recognized as the highest indicator, distinguished by 8 varieties, they are: Bekes, Hajnal, Goncol, Tisza, Csillag, Futar, Garaboly and Szala. The NDVI of these varieties was higher than 0.75. During the flowering period of wheat development, the highest index index was observed (figure 2), during this period, the biomass index was in the range of 0.70-0.80. It was found that the biomass index above 0.80 is 11 varieties, including Ati, Bekes, Bereny, Mentor, Hajnal, Goncol, Tisza, Csillag, Petur, Garaboly and Rozi (table 2).

Table 2- Wheat samples biomass index (NDVI), Almaty region, 2019

Cultivar	Plant Biomass Index (NDVI)			Average values
	Heading period	Flowering period	Period of milk ripeness	
Ati	0,72	0,81	0,59	0,71
Bekes	0,76	0,80	0,46	0,67
Bereny	0,69	0,77	0,52	0,66
Kalasz	0,73	0,72	0,56	0,67
Koros	0,68	0,74	0,56	0,66
Mentor	0,71	0,81	0,63	0,72
Hajnal	0,77	0,78	0,66	0,74
Goncol	0,79	0,77	0,65	0,74
Tisza	0,75	0,78	0,66	0,73
Csillag	0,76	0,78	0,66	0,73
Futar	0,77	0,73	0,64	0,71
Feny	0,71	0,74	0,63	0,69
Pilis	0,68	0,73	0,56	0,66
Petur	0,68	0,80	0,58	0,69
Garaboly	0,76	0,80	0,56	0,71
Szala	0,79	0,73	0,72	0,75
Szemes	0,72	0,73	0,57	0,67
Vitorlas	0,72	0,74	0,59	0,68
Rege	0,69	0,73	0,59	0,67
Raba	0,71	0,73	0,54	0,66
Rozi	0,73	0,79	0,54	0,69
Bogarnaya 56	0,71	0,73	0,54	0,66

During the period of wheat ripening, the biomass index above 0.65 was recognized as a high indicator of 8 varieties that have Mentor, Hajnal, Goncol, Tisza, Csillag, Futar, Feny and Szala.

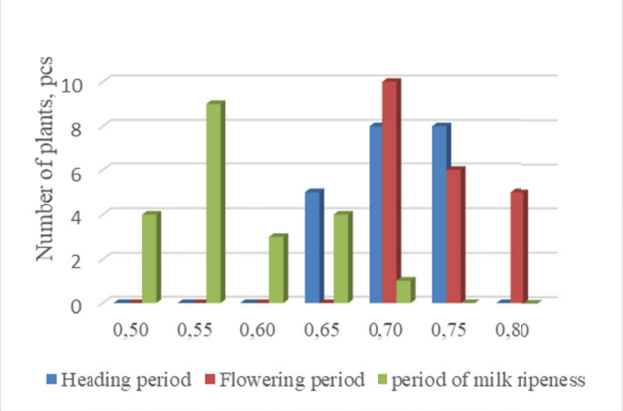

Figure 2 – Biomass index dynamic (NDVI)

Thus, the biomass index (NDVI) of the histology, flowering, and molestation stages of plants had a high index of 9 varieties, with an average index value (NDVI) higher than 0.70, as shown by Ati, Mentor, Hajnal, Goncol, Tisza, Csillag, Futar, Garaboly, and Szala. In our next study, we analyzed the structural features of mature wheat samples. We can see that the germination period of wheat varieties lasted from May 22 to June 2. The earliest ears: Ati, Bekes, Bereny, Koros, Hajnal, Tisza, Csillag, Futar, Feny, Pilis, Garaboly and Vitorlas. The flowering period of these varieties is from May 22 to May 25. The height of all wheat varieties in plant height is 85-108 cm. 6 varieties of wheat with an Ear length of more than 10 cm were distinguished by a high indicator, they; Bekes, Mentor, Tisza, Garaboly, Szemes, and Rege (table 3).

Table 3 - Structural analysis of cultivars wheat, Almaty region, 2019

Cultivar	Days to heading	Plan height (cm)	Spike length (cm)	Kernels/ spike	Grain weight/spike, pcs	Grain weight/spike (g)	Thousand kernel weight (g)
Ati	24.05.2019	85	7,50±0,22	19,0±2,00	46,2±6,21	1,60±0,46	35,55
Bekes	25.05.2019	94	10,85±1,96	20,6±1,20	50,5±5,55	2,40±0,28	46,74
Bereny	25.05.2019	84	9,32±0,39	22,5±1,36	62,9±9,80	1,80±0,50	30,75
Kalasz	26.05.2019	89	9,11±0,37	20,9±1,14	35,6±4,89	1,70±0,27	53,26
Koros	24.05.2019	87	8,96±0,38	21,6±1,28	59,3±6,84	2,50±0,26	43,8
Mentor	27.05.2019	94	12,32±0,33	20,9±0,83	69,2±6,83	2,85±0,39	41,05
Hajnal	25.05.2019	88	9,14±0,66	20,9±1,81	38,1±9,32	1,58±0,48	40,51
Goncol	26.05.2019	86	8,31±0,89	20,4±1,50	43,3±5,52	1,85±0,26	42,37
Tisza	23.05.2019	84	11,08±0,80	21,9±1,22	55,0±6,73	2,23±0,35	40,82
Csillag	24.05.2019	88	7,32±0,75	18,4±0,92	40,8±5,07	1,32±0,13	34,51
Futar	22.05.2019	85	9,61±0,85	19,6±1,43	31,2±14,86	1,27±0,15	50,93
Feny	25.05.2019	100	9,23±0,56	21,5±1,28	48,4±6,64	1,82±0,31	37,93
Pilis	24.05.2019	93	8,25±0,35	18,8±0,98	52,2±8,59	2,16±0,26	42,8
Petur	30.05.2019	87	8,44±0,72	21,6±0,92	53,2±7,26	1,62±0,37	35,48
Garaboly	23.05.2019	73	10,45±1,10	21,4±2,33	56,2±9,19	1,57±0,40	32,13
Szala	02.06.2019	98	8,56±0,63	21,7±1,49	59,2±4,59	2,34±0,32	43,84
Szemes	28.05.2019	105	10,36±0,49	24,6±3,29	74,1±10,62	2,19±0,36	29,57
Vitorlas	23.05.2019	81	8,78±1,14	18,9±1,30	36,1±7,39	1,43±0,27	41,3
Rege	26.05.2019	108	11,27±1,11	24,7±4,29	69,0±16,97	2,64±0,72	38,41
Raba	28.05.2019	99	9,26±1,11	19,9±1,97	48,3±3,10	1,58±0,35	33,74
Rozi	27.05.2019	92	7,48±0,51	20,9±1,45	46,6±9,13	1,42±0,41	33,21
Bogarnaya 56	25.05.2019	110	9,7±21	20,12±1,33	40,3±32	1,60±36	44,65

The number of ears of more than 21 samples showed high indicators of 9 varieties: Bereny, Koros, Tisza, Feny, Petur, Garaboly, Szala, Szemes and Rege. The amount of grain in the main ear was more than 55 pieces; varieties Bereny, Koros, Mentor, Tisza, Garaboly, Szala, Szemes and Rege were found to be high. Bekes, Koros, Mentor, Tisza, Pilis, Szala, Szemes and Rege varieties with a grain weight of more than 2 grams in the main ear showed high indicators. Bekes, Kalasz, Koros, Mentor, Hajnal, Goncol, Tisza, Futar, Pilis, Szala and Vitorlas showed the highest indicators for the weight of 1000 seeds.the weight of 1000 seeds of these varieties exceeded 40 grams.

Discussion. T. caries fungal pathogens are the major actors for common bunt disease. This disease is very dangerous seed borne disease for wheat and causes heavy losses in yield quality and quantity [34]. Since 2018, we have been searching for reliable sources of resistance to smut of wheat among collection samples of domestic and foreign selection from around the world during artificial infection, studying their

biological characteristics and economically valuable traits [30, 31, 32, 35]. As part of an artificial epidemic, the Hungarian 21 wheat cultivar has been tested Tilletia caries (D.C.) Tul. & C. Tul resistance to the pathogen. The study distinguished 8 wheat varieties that are highly resistant to the common bunt, they are Ati, Békés, Berény, Csillag, Futár, Pilis, Szala and Rege. 7 varieties were found to be stable, which are, Kalász, Mentor, Göncöl, Fény, Garaboly, Szemes and Vitorlás. The biomass index (NDVI) was calculated at the vegetative stages of wheat development. The biomass index of Bekes, Hajnal, Goncol, Tisza, Csillag, Futar, Garaboly and Szala varieties was high. during the flowering period, the indices of ATI, Bekes, Bereny, Mentor, Hajnal, Goncol, Tisza, Csillag, Petur, Garaboly and Rozi samples were recognized as high. During the milking period of wheat, the highest indicators of the index's biomass are: Mentor, Hajnal, Goncol, Tisza, Csillag, Futar, Feny, and Szala. As a result of the analysis of structural features of economically valuable wheat varieties Koros, Mentor, Tisza, Szala, Szemes and Rege showed high indicators for all features. With the early Ear, 12 varieties of wheat were distinguished, such as Ati, Bekes, Bereny, Koros, Hajnal, Tisza, Csillag, Futar, Feny, Pilis, Garaboly, and Vitorlas. These varieties can be submitted to the breeding program as a model that is resistant to diseases of the common bunt. Recently held studies aimed at assessing sustainability germplasm of wheat to smut [18]. Screening of large pools of genotypes comprising commercial and historical varieties, breedding lines, and old local accessions revealed very low levels of resistance [21]. The search for new sources of resistance would enhance the genetic diversity available for breeding purposes.

Conclusion. Thus, our research data allowed us to expand the range of sources and donors of wheat resistance to smut. To increase the efficiency and effectiveness of breeding programs designed to increase the resistance of breeding material and, in the future, varieties, the released sources were comprehensively evaluated for economic utility. Given the presence and absence of important agronomically valuable traits among the selected sources, the selection of parental pairs for hybridization should be carried out.

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БИДАЙДЫҢ ҚАТТЫ ҚАРАКҮЙЕГЕ (TILLETIA CARIES (DC.) ТӨЗІМДІЛІГІНЕ СКРИНИНГ

Аннотация. Қатты қоқыс (Tilletia caries (DC.) күздік бидай өсірілетін жерлерде кездеседі. Елімізде аудандастырлған бидай сорттарының басым бөлігі аталған аурумен залалданған. Сондықтан шетелдік гермоплазмалардан төзімділік көзін іздеу керек.

Зерттеулерімізде танапты жасанды індеттік ортада венгриялық 21 жұмсақ бидай сортының *Tilletia caries* (DC.) патогеніне фитпатологиялық және генетика-селекциялық талдау жүргізілді. Зерттеу нәтижесінде 15 бидай сорты ауруға төзімді деп анықталды, соның ішінде 8 бидай сорты ауруға жоғары төзімді (IT – 0) деп ерекшеленді. Олар мыналар: Ati, Bekes, Bereny, Csillag, Futár, Pilis, Szala, Rege. Қатты қарақүйеге төзімді (IT – 1) деп 3 сортты айтамыз, олар: Fény, Szemes, Garaboly. Әлсіз төзімсіз тобына 6-25% есепке алыну бойынша 8 сорт (Kalász, Mentor, Hajnal, Göncöl, Tisza, Vitorlás, Rába, Rozi) анықталды. Төзімсіз сорт ретінде Körös (ауру 26-50%) сорты байқалды. *Tilletia caries* (D.C.) патогенімен 69%-бен залалданған Petur сорты жоғары деңгейде төзімсіздік танытты.

Индекс биомасса көрсеткішінің орташа мәні 0,70-тен жоғары болған 9 сорт жоғары көрсеткішке ие деп ерекшеленді, олар: Ati, Mentor, Hajnal, Göncöl, Tisza, Csillag, Futár, Garaboly және Szala.

Құрылымдық белгілеріне талдау нәтижесінде Körös, Mentor, Tisza, Szala, Szemes және Rege сорттары барлық белгілері бойынша жоғары көрсеткіш көрсетті. Нәтижесінде ауруға төзімді және өнімділігі жоғары сорттарды иммунитет селекциясында қатты қарақүйеге төзімді үлгілер ретінде ұсынуға болады.

Түйін сөздер: бидай, патоген, инокуляция, қатты қарақүйе, төзімді.

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СКРИНИНГ НА УСТОЙЧИВОСТЬ К ТВЕРДОЙ ГОЛОВНЕ (TILLETIA CARIES (DC.) ПШЕНИЦЫ

Аннотация. Твердая головня (Tilletia caries (DC.) встречается в районах, где выращивается озимая пшеница. В нашей стране большинство районированных сортов пшеницы заражены этим заболеванием. Поэтому источники устойчивости следует искать в зарубежных гермоплазмах. В наших исследованиях в области искусственной эпизоотической среды на венгерском 21 сорте мягкой пшеницы Tilletia caries (DC.) возбудителя был проведен фитопатологический и генетико-селекционный анализ. В результате исследования было выявлено, что 15 сортов пшеницы устойчивы к болезням, из которых 8 сортов пшеницы были высокоустойчивы к болезням (ИТ-0). Это: Ати, Бекес, Берени, Чиллаг, Футар, Пилис, Сала и Риге. Слабовосприимчивыми оказались 8 сортов, поражаемость составила 6-25% (Kalász, Mentor, Hajnal, Göncöl, Tisza, Vitorlás, Rába, Rozi). Восприимчивым оказался сорт Körös (поражаемость 26-50%). Патогеном Tilletia caries (D.C.) на 69% заразился сорт Petur и проявил высокую восприимчивость. Среднее значение показателя индекса биомассы выше 0,70 показали 9 сортов пшеницы Ati, Mentor, Hajnal, Göncöl, Tisza, Csillag, Futár, Garaboly и Szala. В результате анализа структурных характеристик сорта Кереш, Ментор, Тиса, Шала, Шемес и Реге показали высокий индекс по всем признакам. В результате устойчивые к болезням и высокоэффективные сорта могут быть представлены в программу селекции в качестве модели, устойчивой к твердой головне пшеницы.

Ключевые слова: пшеница, патоген, инокуляция, твердая головня, устойчивость.

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