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THE DIFFERENTIATION OF WINTER WHEAT (*Triticum aestivum* L.) CULTIVARS FOR RESISTANCE TO THE MOST HARMFUL FUNGAL PATHOGENS

M.I. KISELEVA[1], T.M. KOLOMIETS[1], E.V. PAKHOLKOVA[1], N.S. ZHEMCHUZHINA[1], V.V. LUBICH[2]

[1]*All-Russian Research Institute of Phytopathology,* Federal Agency of Scientific Organizations, 5, ul. Institute, pos. Bol'shie Vyazemy, Odintsovskii Region, Moscow Province, 143050 Russia, e-mail kiseleva@vniif.ru, kolomiets@vniif.ru, pakholkova@vniif.ru, zhemch@mail.ru;
[2]*Uman State University of Horticulture,* vul. Institutska, 1, Uman, Cherkaska obl., Ukraine 20305, e-mail lyubichv@gmail.com
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Abstract

Genetic homogeneity of wheat crops possessing inefficient resistance genes, together with large variability in the mycopathogen virulence result in increasing losses of the harvest from fungal diseases worldwide. Therefore, the persistent long-term resistance varieties are the main element in the strategy of integrated plant protection aimed at reducing risk of environmental pollution by fungicides. Updating the set of such varieties preserving efficiency in different agricultural systems, the regional planning of their placement in crops would be more effective to provide protection against mycopathogens and to constrict the spread of new virulence genes. We first performed a comprehensive assessment of resistance to major fungal pathogens for winter wheat varieties of different ecogeographical and breeding origin from the VIR World Collection (N. I. Vavilov All-Russian Institute of Plant Genetic Resources, St. Petersburg), the collections of Krasnodar Research Institute of Agriculture (KNIISH, South of Russia) and Nemchinovka Moscow Research Institute of Agriculture (MRIA, Central Russia). The goal was to select the donors of resistance to adverse biotic factors, including the most harmful diseases: brown rust (*Puccinia triticina* Eriks.), stem rust (*P. graminis* Pers.), powdery mildew (*Blumeria graminis* (DC.) Speer f. sp. *tritici* Marchal.), Septoria (*Septoria tritici* Rob. et Desm. and *Stagonospora nodorum* Berk.) from the collections of VIR, KNIISH and MRIA. Among 158 winter wheat cultivars the field resistance to leaf rust has been showed in 8.9 %, to stem rust in 5.1 %, and to *Septoria* spp. in 1.3 %. No wheat cultivars were resistant to powdery mildew. Evaluation of wheat seedling resistance to leaf rust in a climatic chambers allowed to identify samples with adult and race-specific resistance. The Ukrainian varieties differed geographically in resistance to the leaf rust. The varieties resistant to two or more pathogens were the most important. Cultivars Junona, Tanya (KNIISH), Bogdanka (derived from Belgorod region.) have been possessed the resistance to leaf and stem rust. Cultivars Borvij, Zagrava odes'ka (Ukraine), Catalus (Germany) were partial resistant to leaf rust and moderate susceptible to *Septoria* spp. Cultivars Gyrmyzy Gjul' 1 (Azerbaijan), Catalus (Germany) were important due to their combined resistance to *Septoria tritici* and *Stagonospora nodorum*. KS 93450 (USA) has combined partial resistance to leaf rust, moderate susceptibility to *Septoria* spp. and stem rust resistance. These samples can be further used in breeding.

Keywords: winter wheat, *Triticum aestivum* L., cultivar, pathogen, *Puccinia triticina*, *Puccinia graminis*, *Blumeria graminis*, *Septoria tritici*, *Stagonospora nodorum*, selection, race-specific, partial, adult plant resistance

Brown rust (*Puccinia triticina* Eriks.), stem rust (*P. graminis* Pers.), powdery mildew (*Blumeria graminis* (DC.) Speer f. sp. tritici Marchal.), Septoria (*Septoria tritici* Rob. et Desm. and *Stagonospora nodorum* Berk.) are most harmful fungal diseases of bread wheat (*Triticum aestivum* L.). Annual losses caused by these pathogens amount from 10-40 % to total crop loss in the years of strong epiphytoties [1, 2].

Significant variability in virulence and high mutation frequency are characteristic of these pathogens leading to emerging and accumulation of virulence genes in natural populations which can overcome effective R-genes in wheat [3-

5]. Moreover, high reproduction and migration activity of the pathogens also contribute to diseases development [6, 7]. The appearance of new aggressive stem rust and brown rust races and wide cultivation of susceptible wheat varieties naturally leads to an increase in crop losses [8, 9].

Brown rust is mostly spread and harmful in Russia. Noteworthy, closely related wheat varieties which are genetically similar, occupy more than a half of wheat cultivation area, while the gene pool of local varieties adapted to adverse biotic and abiotic factors, is depleted and changed, which increases the crop susceptibility to the pathogen [10]. Thus, few years after an increase in cultivation area of winter wheat variety Moskovskaya 39 with the race-specific resistance gene *Lr1* in Non-Chernozem zone the occurrence frequency of brown rust race with *p1* virulence gene increased from 40 % to 100 % [11]. In Western Siberia, due to cultivation of winter wheat varieties with effective *Lr9* genes, brown rust races possessing *p9* virulence gene have been identified in large areas [12]. Gene *Lr19* was effective in domestic varieties for more than 40 years, but after it was used in breeding varieties widely cultivated in the Volga region and the Urals, new rust races with *p19* were found. They were first identified in 1997 in Saratov Province on L 503 and L 505 crops [12]. The *p19*-gene races quickly spread on wheat crops in the Central Black Earth, Central, Volga-Vyatka, and other regions of the European Russia, and in 2000-2003 they were found in Western and Eastern Siberia and the Primorskii Krai [13]. In all these cases, the main reason for loss of race-specific resistance to brown rust in wheat varieties was an increase in their acreage.

High natural mutagenesis and recombination processes in the stem rust pathogen populations also lead to the emergence and rapid spread of new aggressive and virulent races, which cause severe epiphytotics on cereal crops in many countries [14, 15]. So, the wheat stem rust race UG 99, first identified in Uganda in 1988, then spread to the East and North Africa, and the Near East, causing devastating epiphytotics on crops of previously resistant varieties in Kenya, Ethiopia, Yemen, Sudan and Iran. The virulent and aggressive race UG 99 has been able to adapt quickly to a wide range of temperature conditions in the countries on different continents [16]. In connection with the race UG 99 advent, the International Program was adopted by the International Center for Maize and Wheat Improvement (International Maize and Wheat Improvement Center, CIMMYT) which included the identification of new potentially dangerous races of not only stem rust, but also other rusts. International infectious nurseries have also been organized with the use of differential wheat varieties as the markers for resistance to fungal populations. According to the program, new stem rust-resistant wheat varieties should be based on different combinations of specific race-resistance genes, small genes conferring long resistance and *Sr 2* gene slowing the progression of the disease. However, the evaluation of wheat varieties and specimens from 22 countries revealed that 80 % of them were susceptible to UG 99 [16].

Powdery mildew epiphytotics in wheat are much less common than rust epiphytotics. Developing before earing, the disease leads to deterioration of grain formation, and reduces the grain size, which ultimately affects adversely the yield. Powdery mildew dramatically reduces plant resistance to drought, accelerates leaf death, so it is most harmful in dry years [17, 18).

Septoria (*Septoria tritici* Rob. et Desm. and *Stagonospora nodorum* Berk.) mainly affects the leaves and leaf sheaths, and the reproductive organs. The disease is widespread, but dominated and most nocuous in the North West, Volga-Vyatka, North Caucasian regions, in the Urals, Eastern and Western Siberia and the Primorskii Krai of the Russian Federation, the Baltic countries, Belarus, Kazakhstan and Kyrgyzstan. Epiphytotics occur 4 times per 10 years on the average. The main reason for high disease severity is absence of resistant varieties [19].

Thus, the creation of resistant wheat varieties sustainably effective in various agrosystems is of increasing significance in recent decades. In this, for correct evaluation of genotype resistance it is important to infect plants artificially with all diversity of the pathogen with regard to its virulence and aggressiveness given that, at the same time, the favorable conditions for disease development are maintained. Meeting these requirements allows for objective estimation of the nature of the host-pathogen relations and resistance types [11, 20, 21]. Over 5,000 winter and spring wheat variety accessions from the VIR World Collection (Federal Research Center the N.I. Vavilov All-Russian Institute of Plant Genetic Resources, St. Petersburg, Russia), CIMMYT (Mexico), National Small Grains Collection (NSGC, USA), Kazakhstan-Siberian Network on Wheat Improvement (KASIB, Omsk, Russia), and wheat collections of Russian breeding centers have been evaluated in the infectious nurseries of All-Russian Research Institute of Phytopathology for last 10 years. These were the varieties from North and South America, Asia, Eastern and Western Europe, Africa and Australia. The USA, Canadian, Mexican, Argentinian and Chinese varieties have been the most representative [11, 22].

Different disease resistance types are involved in breeding. These are the juvenile, adult or partial resistance, as well as their combination. Age-dependent and partial resistance is of special interest due to conferring long-term protection [23-25]. Genes for age resistance provide longer-lasting effect due to less time of selective pressure on the pathogen population. Besides, this resistance type is easy to combine with seedling resistance thus reaching long-time resistance to brown rust and other wheat diseases [26-28].

It should be emphasized the importance of joint research and the exchange of breeding material between the scientists from CIMMYT and Kazakhstan and Western Siberia. «Shuttle breeding» allows to use world gene pool to generate the varieties with long-lasting drought and diseases resistance, and test parents more accurately at contrasting environments of Central America (Mexico), Africa (Kenya) and Eurasia (Kazakhstan and Russia), revealing the most competitive hybrid populations resistant to wide range of brown and stem rust races [29, 30].

We first carried out a comprehensive assessment of the resistance to most harmful fungal pathogens in various eco-geographical wheat accessions of different genetic origin from the VIR World Collection, Krasnodar Research Institute for Agriculture (KNIISH) collection (Southern Russia) and «Nemchinovka» Moscow Research Institute for Agriculture (MRIA, Central Russia).

The focus of this study was to test accessions and breeding winter wheat samples to select sources and donors for resistance to the most common and harmful fungal pathogens.

Technique. Resistance of 158 specimens of winter wheat (*Triticum aestivum* L.) form three collections to brown rust *Puccinia triticina* Eriks., stem rust *P. graminis* Pers., powdery mildew *Blumeria graminis* (DC.) Speer f. sp. *tritici* Marchal., Septoria (*Septoria tritici* Rob. et Desm. and *Stagonospora nodorum* Berk.) were studied in infectious nursery (Moscow Province) in 2015 when sowing at least 700 grains per 1 m^2 on September 8, 2014. Powdery mildew and stem rust resistance was estimated at natural infection, while for assessing brown rust and Septoria resistance the plants were infected artificially. Khakasskaya line plants were used as a standard for brown rust and powdery mildew susceptibility and grown along the sides of the experimental plots to allow for development of the pathogen populations.

A spore mixture of natural isolates from Moscow Province with virulence genes *p1*, *p2a*, *p2b*, *p2c*, *p3a*, *p3ka*, *p3bg*, *p9*, *p10*, *p11*, *p14a*, *p14b*, *p15*, *p16*, *p17*, *p18*, *p19*, *p20*, *p21*, *p23*, *p25*, *p26*, *p27+31*, *p28*, *p30*, *p32*, *p33*, *p36*, *p39*, *p40*, *p46* and *pB* was used. In III decade of May, at the end of stem elongation to early earing, the plants were inoculated with spores mixed with talc (1:100, the spore load of 15 mg per 1 m^2). Evening dewfall (relative humidity of 90 %, 20 °C) was most favorable for inoculation. Since day 10 post inoculation, the crops were surveyed each 5-7 days. Disease development was estimated according to the modified Cobb scale for both quantitative (disease intensity, %) and qualitative (scoring plant reaction) parameters [31].

When estimating juvenile resistance to brown rust in a climatic chamber, the 5 day old seedlings were inoculated with the mixture of local *P. triticina* pathotypes. Reaction was recoded on day 12 using E.B. Mains and H.S. Jackson scale [32] with «0», «0;», «1», «2», «X–» for resistance, and «3», «4», «X+» for susceptibility.

Additionally to brown rust, we observed natural powdery mildew and stem rust infections. In this, the modified E.E. Saari and J.M. Prescott scale for powdery mildew [33], and the scales of R.F. Peterson et all. [31] and R.A. McIntosh et all. [34] for stem rust were used.

Resistance to Septoria diseases was assessed in field plot experiment using mixtures of aggressive *Stagonospora nodorum* and *Septoria tritici* strains from Moscow Province for artificial infection. *S. nodorum* and *S. tritici* suspensions contained 10^6 and 10^7 conidia/ml, respectively. The inoculum was hand sprayed at the dosage of 100 ml/m^2. Test plants were inoculated with *Septoria tritici* on May 21, and then with *Stagonospora nodorum* on June 9. Plant lesion was scored according to the E.E. Saari and J.M. Prescott sale [33]. Since day 10 post inoculation, the crops were surveyed each 5-7 days.

Agronomic traits and disease resistance were evaluated in the nursery of Uman State University (Ukraine) in 2011-2012.

The lesions were determined not less than in 100 plants of each variety. LSD_{05} parameter was used in statistical processing.

Results. The tested plants overwintered satisfactorily, despite frequent thaws in the spring and winter. After brown rust inoculation in III decade of May the first symptoms of the diseases occurred in susceptible varieties only in III decade of June. It can be due to low air humidity (54 % against 69 % of a ten-day norm) and no precipitation from the end of May to the beginning of June (0 mm against 22.0 mm on average).

In II and III decades of June the precipitations exceeded the long-term averages (40.1 and 50.7 mm against 21.7 and 24.3 mm, respectively), the relative humidity was about normal (62 and 73 %) while the temperature (16.9 and 18.1 °C against the average of 16.2 and 17.1 °C) were favorable for the fungal pathogen development. The first symptoms of 10-15 % disease intensity occurred on the lower leaves in flowering Khakasskaya plants on June 20. In 4 days the brown rust (*P. triticina*) symptoms with 5-40 % intensity were observed in some specimens, whereas in Khakasskaya plants it increased from 15 to 60 % from June 20 to 24.

In Khakasskaya variety the infection reached a peak on July 1, in other varieties it was July 8, so 2 weeks passed from appearance of the first symptoms to a maximum injury. The studied winter wheat accessions varied considerably by the type of pathogen resistance (Table 1). At that, most varieties showed susceptibility to brown rust with 60-100 % leaf lesions.

1. Resistance to brown rust (*Puccinia triticina* Eriks.) and diseases intensity in studied winter wheat (*Triticum aestivum* L.) accessions (infectious nursery, artificial inoculation; Moscow Province, July 8, 2015)

Collection	*n*	Resistant 0-10 % lesion		Moderately resistant 25-40 % lesion		Susceptible 60-100 % lesion	
		amount	%	amount	%	amount	%
VIR	110	4	3.6	16	14.4	90	82.0
KNIISH	34	10	29.4	11	32.4	13	38.2
MRIA	14	0	0	3	21.4	11	78.6
Total	158	14	8.9	30	18.9	114	72.2

N o t e. VIR — VIR World Collection (Federal Research Center the N.I. Vavilov All-Russian Institute of Plant Genetic Resources, St. Petersburg), KNIISH — collection of Krasnodar Research Institute for Agriculture, MRIA — collection of «Nemchinovka» Moscow Research Institute for Agriculture.

2. Characterization of some studied winter wheat (*Triticum aestivum* L.) varieties of different origin on brown rust (BR), **stem rust** (SR) **and powdery mildew** (PM) **resistance**

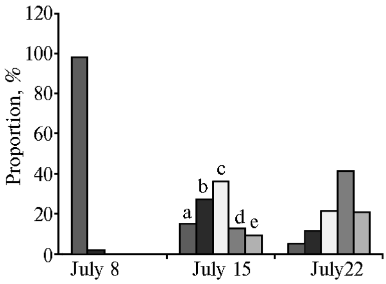
Variety (VIR Collection number)	Species	Origin	BR: lesion score in seedlings[1]	BR: flag leaf lesion, %[2]	BR: type	PM lesion, %	SR lesion, %
Aivina	Soft wheat	KNIISH	0; 1	0	S	40	10
Bat'ko	Soft wheat	KNIISH	0; 1	0	S	40	10
Brigada	Soft wheat	KNIISH	X+	25	P	40	10
Liga 1	Soft wheat	KNIISH	0; 1	0	S	40	23
Zinitsa	Soft wheat	KNIISH	0; 1	0	S	40	40
Zitra	Soft wheat	KNIISH	0; 1	0	S	40	10
Kralya	Soft wheat	KNIISH	0; 1	0	S	40	40
Tanya	Soft wheat	KNIISH	0; 1	0	S	40	0
Tvorets	Soft wheat	KNIISH	0; 1	0	S	40	10
Fisht	Soft wheat	KNIISH	0; 1	0	S	20	25
Yumpa	Soft wheat	KNIISH	X+	25	P	40	40
Yunona	Soft wheat	KNIISH	0; 1	0	S	40	0
Pamyat'	Soft wheat	KNIISH	X+	40	P	40	80
Etnos	Soft wheat	KNIISH	X+	25	P	60	25
Vassa	Soft wheat	KNIISH	3, 4	25	P	60	10
Vostorg	Soft wheat	KNIISH	3, 4	25	P	40	25
Dmitrii	Soft wheat	KNIISH	3, 4	40	P	20	60
Nota	Soft wheat	KNIISH	3, 4	40	P	40	10
Proton	Soft wheat	KNIISH	X+	25	P	40	80
Sila	Soft wheat	KNIISH	3, 4	25	P	40	80
Tabor	Soft wheat	KNIISH	3, 4	40	P	40	40
Afina	Soft wheat	KNIISH	4	60	SC	40	0
Intrada (k-65397)	*graecum*	USA	1, 2	40	P	40	10
KS 96 WOKC39 (k-65393)	*lenugincum*	Canada	0; 1	0	S	40	10
Bogdanka (k-65078)	*erythrospermum*	Belgorod Province	; 1, 2	0	S	40	0
Uzhynok (k-60517)	*erythrospermum*	Ukraine	; 1–	0	S	60	40
Batis (k-65428)	*lutescens*	Germany	3	10	A	20	10
Maclyarka (k-65358)	*lutescens*	Ukraine	2, 3	40	P	20	10
Odes'ka 200 (k-65366)	*erythrospermum*	Ukraine	3, 4	40	P	20	10
Amigo (k-65405)	*erythrosperrnum*	USA	3, 4	25	P	60	25
Yumar (k-65400)	*ferrugineum*	USA	3, 4	25	P	40	10
Ugur (k-65418)	*lutescens*	Azerbaijan	3	25	P	40	10
Don 95 (k-64622)	*lutescens*	Rostov Province	X+	10	P	40	10
Kalita (k-65071)	*erythrospermum*	Ukraine	4	40	P	40	25
Akord (k-65296)	*lutescens*	Ukraine	3, 4	25	P	40	40
Borvij (k-65298)	*erythrospermum*	Ukraine	X+	40	P	40	60
Vidrada (k-65299)	*erythrospermum*	Ukraine	X+	40	P	40	60
Zagrava odes'ka (k-65304)	*erythrospermum*	Ukraine	3	40	P	40	60
Catalus (k-65324)	*lutescens*	Germany	3, 4	25	P	40	10
Perfect (k-65326)	*lutescens*	Germany	3, 4	25	P	40	40
Samurai (k-65328)	*lutescens*	Germany	3, 4	40	P	60	0
Emmit (k-65330)	*lutescens*	Germany	3, 4	25	P	40	0
Donshchina	No data	Ukraine	3, 4	40	P	60	40
Snizhana	No data	Ukraine	3, 4	40	P	40	0
KS 93450	No data	USA	3, 4	40	P	40	0

N o t e. VIR — Federal Research Center the N.I. Vavilov All-Russian Institute of Plant Genetic Resources (St. Petersburg), KNIISH — Krasnodar Research Institute for Agriculture; 1 — climatic chamber, 2 — field trials (infectious nursery of All-Russian Research Institute of Phytopathology, Moscow Province, 2015). E.B. Mains and H.S. Jackson scale scoring (see section «Technique»). S, P and A mean specific, partial and age resistance, respectively; SC means susceptible type.

The resistant varieties were Aivina, Bat'ko, Liga 1, Kralya, Zimnitsa, Zitra, Yunona, Tanya, Tvorets, Fisht from KNIISH collection in which such a type was most abundant. In these varieties the brown rust resistance is most likely race-specific, since no symptoms of the disease were observed both in the climatic chamber, and in the field trials (Table 2). In varieties KS 96 WOKC39 (Canada), Bogdanka (Belgorod Province) and Uzhynok (Ukraine) from the VIR World Collection the resistance was also race-specific, whereas in Batis (Germany) it was age-related, since the seedlings were moderately susceptible to brown rust while the plants at flag leaf stage were resistant in field trials (see Table 2).

In the moderately resistant varieties (a total of 30 samples, or from 14.4 to 32.4 % of accessions), the disease progression was delayed, and by the end of the growing the disease intensity did not exceed 25-40 %.

In I decade of July air temperature elevated (19.4 °C compared to 17.8 °C on average) and favorable for stem rust development. First symptoms were recorded on July 8 at wax ripeness in Ermak, Zarnitsa and Khakasskaya varieties as rare, small immature pustules of the fungus on the lower parts of the stems. Then, on July 15 and 22, the number of stem rust-affected varieties increased (Fig.). At the same time the plant injury increased reaching 100 % in Ermak and Zarnitds varieties. The fungus populated stems, leaves, actively developed even on the ears. Because of natural death of plants further survey was not reasonable.



Distribution of 158 soft winter wheat (*Triticum aestivum* L.) accessions on immunity (a)**, resistance** (b)**, moderate resistance** (c)**, moderate susceptibility** (d) **and susceptibility** (e) **to stem rust** (infectious nursery, Moscow Province, 2015).

Thus, the varieties Afina, Yunona, Tanya (KNIISH), Bogdannka (Belgorod Province), Snizhana (Ukraine), Samurai, Emmit (Germany), KS 93450 (USA) were stem rust-resistant in the plot trials of year 2015 (see Table 2).

The rainfall favored mildew appearance on winter wheat crops in the middle of III decade of June. The symptoms were first observed on lower leaves, and to I decade of July in all varieties the flag leaves have been 40-80 % damaged. In some plants stems and ears were also affected. The strong development of rust fungi, as well as natural leaf death and plant senescence during grain maturation hindered further study.

The weather favored Septoria disease development, too. All plants were inoculated with *Septoria tritici* and *Stagonosporum nodorum* consecutively with 20 days interval, at stem elongation and earing when they were most susceptible to the pathogens, whereas the final plant resistance was estimated with regard to both pathogens. As these fungi naturally co-exist on the crops, and the inoculum used was a mixture of local isolates, in our opinion, this mostly corresponded to natural infection. Strong injury (up to до 80 %) caused by *Septoria tritici* was first detectable on the lower leaves on June 10 at earing, then reaching a peak in III decade of June at flowering. In about a half of tested varieties the flag leaves were 5-40 % affected. When inoculating on June 9 with *Stagonosporum nodorum* at earing, only flag leaves and ears were affected. In some varieties *Septoria* spp. symptoms on ears were first detectable in I decade of July. On flag leaves the disease reached the highest intensity (80-100 %) on July 8, and on ears this was on July 27 (65 %). Tested accessions from different genetic collections were mostly susceptible and high susceptible to Septoria with leaf damage of 65 to 100 %, except the varieties Carifen (Chile) and Gyrmyzy Gjul' 1 (Azerbaijan) which were low susceptible.

Note that the resistance to Septoria was more clearly differentiated only by the ears (Table 3). In this, only 12 varieties of 108 accessions from VIR Collection were not affected, with special attention to Gyrmyzy Gjul' 1 (Azerbaijan) and Catalus (Germany) as resistance donors. Low ear lesions were observed in Hospodynia, Borvij, Vil'shana, Epokha odes'ka, Zagrava odes'ka, Sagajdak, Antonivka (Ukraine), Carifen (Chile), Finch, KS 93450 (USA).

3. Ear-based characterization of winter wheat (*Triticum aestivum* L.) collections on resistance to Septoria disease (infectious nursery, Moscow Province, 2015)

Collection	*n*	R		MS		S		SS	
		number	%	number	%	number	%	number	%
VIR	108	2	1.9	10	9.3	89	82.4	7	6.4
KNIISH, MRIA	42	0	0	0	0	35	83.3	7	16.7
Total	150	2	1.3	10	6.7	124	82.7	14	9.3

N o t e. VIR — VIR World Collection (Federal Research Center the N.I. Vavilov All-Russian Institute of Plant Genetic Resources, St. Petersburg), KNIISH — collection of Krasnodar Research Institute for Agriculture, MRIA — collection of «Nemchinovka» Moscow Research Institute for Agriculture; R — resistant, MS — moderately susceptible, S — susceptible and SS — highly susceptible varieties.

4. Yields in winter wheat (*Triticum* spp.) Ukrainian varieties (nursery of Uman State University of Horticulture, Ukraine)

VIR number	Variety	Species	Yield, center per ha	
			2011	2012
k-65342	Remeslivna	*lutescens*	62.1	65.3
k-65344	Demetra	*lutescens*	63.2	73.7
k-65346	Bagira	*lutescens*	97.3	95.7
k-65347	Podolyanka	*lutescens*	91.2	84.1
k-65350	Khurtovyna	*erythrosperrnum*	72.4	76.9
k-65363	Hospodynia	*erythrosperrnum*	88.7	92.3
k-65364	Zustrich	*erythrosperrnum*	60.1	62.7
k-65367	Syrena	*erythrospermum*	89.1	84.2
k-65071	Kalita	*erythrospermum*	77.5	83.6
k-63297	Barvina	*erythrospermum*	79.8	84.3
k-65298	Borvij	*erythrospermum*	72.4	70.5
k-65299	Vidrada	*erythrospermum*	79.4	76.0
k-65300	Vil'shana	*erythrospermum*	73.7	68.0
k-65301	Gerta	*lutescens*	63.7	60.2
k-65302	Epokha odes'ka	*erythrospermum*	77.5	75.1
k-65304	Zagrava odes'ka	*erythrospermum*	70.3	68.6
k-65305	Istyna odes'ka	*lutescens*	100.1	95.6
k-65308	Myronivs'ka storichna	*lutescens*	101.2	97.8
k-65309	Naysel	*erythrospermum*	109.9	110.8
k-65311	Pochayivka	*erythrospermum*	96.0	93.4
k-65313	Roksolana	*erythrospermum*	80.3	78.9
k-65314	Sagajdak	*erythrospermum*	94.7	91.4
k-65315	Sydor Kovpak	*erythrospermum*	86.5	80.6
k-65316	Slavna	*erythrospermum*	110.2	108.9
k-60517	Uzhynok	*erythrospermum*	110.8	109.4
k-65320	Khorevytsya	*ferrugineum*	97.8	102.5
k-65321	Yaroslavna	*lutescens*	92.2	89.7
LSD_{05}			10.1	13.6

N o t e. VIR — VIR World Collection (Federal Research Center the N.I. Vavilov All-Russian Institute of Plant Genetic Resources, St. Petersburg).

As it turned out, of all the sources and donors of winter wheat resistance to fungal diseases we found more than 25 % were Ukrainian varieties. So it was reasonable to compare these data with the tests in the nursery of Uman State University of Horticulture (Ukraine) (Table 4). High and relatively sustainable yields were characteristic of the varieties adapted for cultivation in the forest-steppe of the Right-bank Ukraine. During vegetation under natural fungal infection brown rust was recorded in both years though at insignificant intensity (as a few pustules at the end of the milk ripeness phase). Only leaves at tillering were affected by *Septoria tritici* while no symptoms were observed at stem elongation, earing and milk ripening phases. Nevertheless, in Moscow Province these varieties were strongly affected, probably due to agro-climatic factors and diverse weather conditions influencing life cycle in fungi and plant phenology, and also due to different virulence genes in Ukrainian and Russian Non-Cernozem populations of *Puccinia triticina* and *Septoria tritici*.

Many researchers reported the relationship between the wheat variety susceptibility and the potential virulence of the brown rust causative agent [8, 12, 13, 35-37]. Of 20 monogenic wheat lines only 11 those possessing *Lr2a*, *L3ka*, *Lr9*, *Lr11*, *Lr14b*, *Lr16*, *Lr18*, *Lr20*, *Lr24*, *Lr26* and *Lr28* genes were not affected by Ukrainian population of the pathogen while the rest ones with *Lr1, Lr2c*, *Lr3a*, *Lr3bg*, *Lr10*, *Lr14a*, *Lr17*, *Lr30* and *LrB* genes were susceptible [35]. These nine testers are not used in breeding for resistance [20, 22], and the frequency of their complementary virulence genes in populations of the pathogen in Russia, Ukraine and worldwide reaches 80-100 %. Under conditions of Central Russia the pattern of disease resistance changed, that is, the wheat lines with *Lr2a*, *Lr26* and *Lr28* genes were 7-28 % affected by *P. triticina* isolates, while the lines with *Lr3ka*, *Lr11*, *Lr14b*, *Lr16* and *Lr18* genes were 71-100 % affected [13, 38]. In the infectious nursery we used the pathogen population with more than 30 virulence genes, therefore, a susceptibility of Ukrainian varieties may be due to a gene complementary to a virulence gene in the artificial fungal population.

Thus, under natural and artificial infection we have found the wheat varieties resistant to brown rust (i.e., 13 varieties with race-specific resistance, 30 varieties with partial resistance, and 1 variety with age-dependent resistance), stem rust (8 varieties), and Septoria disease (12 varieties). The varieties expressing resistance to two or more pathogens are of special interest. In particular, the varieties Yunona, Tanya (KNIISH, Krasnodar), Bogdanka (Belgorod Province) were resistant to both brown and stem rusts. The varieties Borvij, Zagrava odes'ka (Ukraine), Catalus (Germany) were partially resistant to brown rust and moderately susceptible to Septoria diseases. KS 93450 (USA) was partially resiant to brown rust, moderately susceptible to Septoria diseases and resistance to stem rust. These specimens may be further involved in breeding for resistance to these pathogens.

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