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Creation of Highly Productive Forms of Winter Wheat with Complex Resistance Against Diseases and Pests on Artificial Infectious Backgrounds of Their Causative Agents

Abstract. Diseases of field crops substantially reduce the yield and quality of the obtained agricultural products. Underselection of gross grain harvest due to diseases and pests can reach about 25-30% annually. This necessitates the creation of resistant varieties for winter wheat selection. The purpose of this study was to create a new highly productive selection material with complex resistance against the main most harmful diseases for further use in the selection of winter wheat. In the phase of emergence of plants in the tube, winter wheat plants were infected with spores of the causative agent of brown rust according to E.E. Heschele's method. To create an artificial infectious background of brown rust, a synthetic population of the pathogen (Institute of Plant Protection of the National Academy of Agrarian Sciences) was used as a reservoir of infection – a susceptible variety of Myronivska 10. To create an artificial infectious background of powdery mildew, a local population and an infectious reservoir of the American variety Keprock were used. In the F_3 hybrid nursery against the provoking background of powdery mildew, combinations highly resistant to the pathogen (up to 5%) were selected, created with sources of resistance: Zdar, Fakon, Pi170911, Bongo – Svitanok Myronivskyi/Zdar, Kolos Myronivshchyny/Fakon, Berehynia Myronivska/Pi170911, Dostatok/Bongo. Resistance against the pathogen (up to 10.0%) was observed in two crossing combinations (Gorlytsia Myronivska/Gloria and Remeslivna/Wervok). Crossing combinations created with sources of resistance were selected on the artificial infectious background of hybrids of the fourth generation for resistance to brown rust: Flex, V 1275, Tobarzo, 203-238. It is worth noting the hybrids: Oberih Myronivskyi/Flex, Smuhlianka/V 1275, Monotyp/Tobarzo, Kolos Myronivshchyna/203-238. The largest number of grains in an ear was obtained from the combination Svitanok Myronivskyi/Zdar (61.5 pieces), and the largest weight of grain from an ear was obtained from the combinations Horlytsia Myronivska/Gloria and Berehynia Myronivska/Pi170911 (2.38 g and 2.37 g, respectively). The Oberih Myronivskyi/Flex combination stood out for its resistance to brown rust and performance elements. The samples selected based on the results of the study are used as valuable raw material to create new winter wheat varieties resistant to diseases in the Forest Steppe of Ukraine

Keywords: *Triticum aestivum* L., source material, sources of resistance, pathogens, powdery mildew, brown rust, variety

INTRODUCTION

One of the main food crops in the world is soft winter wheat. Pathogenic microorganisms accompany it from the moment of sowing until harvesting. Even minimal damage to seedlings by diseases and damage by pests lead to large total losses of the crop [1-3]. One of the key factors that determine the phytosanitary status of grain

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crops is the variety, as its contribution to the future harvest, according to scientists' calculations, can reach up to 70%. Presently, the most economically justified and most effective measure of ecological protection in the context of environmental protection is the creation of varieties highly resistant to a complex of diseases and pests, i.e., selection for resistance. Furthermore, the breeding of new, pest-resistant varieties with high ecological plasticity is one of the primary areas of increasing the yield of agricultural crops. In the system of integrated protection of sowing field crops, emphasis on the cultivation of highly resistant varieties with high productivity has always occupied a special place. It is such varieties that can fulfil the potential possibilities of productivity and quality and provide the greatest return from the agrotechnical techniques used [4; 5].

All plants have natural mechanisms of resistance against harmful organisms, which differ from plant to plant. Breeding work on the creation of varieties of field crops in general and winter wheat, which are resistant to pathogens of major diseases and pests, involves the use of both samples from the world collection and those tested in the conditions of a certain region [6]. The most dangerous and widespread diseases of winter wheat are brown rust, powdery mildew, septoriosis, fusariosis, hard soot, and root rot [2]. Since 2015, an increase in fusarium head blight has been noted in Ukraine, which considerably decreases the quality of flour and bread and leads to a substantial harvest shortage. As showed by H. Buerstmayr *et al.* (2009), H. Kovalyshyna *et al.* (2020) "...grain affected by some species of fusarium, due to its toxicity, becomes unsuitable for human consumption and animal feeding" [7; 8]. In wheat plants affected by root rot, their premature death, a significant manifestation of the spikelet, the invasion of saprophytic fungi on the spikelets, and a decrease in the sowing qualities of the seeds are noted en masse [9]. Young, actively growing wheat plants are more susceptible to damage by powdery mildew, the harmfulness of which is manifested in slowing down the growth and development of plants due to a decrease in the assimilation surface of the leaves, a delay in earing and a slowing down of grain filling, and as a result – a decrease in the content of raw gluten, protein, and starch. As indicated by K.P. Voss-Fels *et al.* (2019) "...harvest failure due to powdery mildew in some cases can reach 10-15%" [6]. Brown rust, causing the greatest damage in the phase of milk ripeness [10], reduces the assimilation surface by 30-40% in winter wheat plants, violates their water balance, causes premature death of leaves and grain brittleness due to increased transpiration [11-13]. Rusty fungi can reduce the content of protein and gluten in grains by up to 20% with severe damage to plants [8; 14]. Harvest losses due to damage by rust up to 40% amount to 30-40 kg/ha, and over 40% can reach 100 kg/ha and more [15-17].

Breeding work aimed at creating ecologically plastic varieties resistant to diseases and pests is one of the main levers of influence on increasing the yield of field crops. Upon studying the immunological properties of the world collection, resistance of individual samples against 2-3 diseases with simultaneous susceptibility to others was revealed [3; 18]. Cultivation of winter wheat varieties with complex resistance against harmful pathogens can guarantee a yield increase of 1.2-1.5 t/ha without protection means. Therefore, the creation of such varieties is the main task of selection [6; 19]. As a result of cultivating varieties of field crops resistant to harmful pathogens and pests, not only does the pesticide load decrease, but also the danger of contaminating the crop and the environment is reduced. [20; 21]. The work on the selection of highly productive forms of winter wheat with complex resistance to diseases and pests on artificial infectious backgrounds and the creation of resistant lines based on them is a complex, multifaceted, creative, and long-term process that involves many years of research with an enormous amount of material. To create a new initial disease-resistant breeding material, it is necessary to replenish and use new sources of resistance.

The tasks of this study were as follows: to investigate the F_2 hybrid material and selection of disease-resistant genotypes of winter wheat on artificial infectious backgrounds of their pathogens (2018); to select highly productive forms of winter wheat with comprehensive resistance to diseases and pests in the F_3 hybrid nursery on artificial infectious backgrounds of their pathogens (2019); to investigate disease-resistant raw material of winter wheat obtained (2020).

The purpose of this study was to find a new genetically diverse selection material resistant to powdery mildew and brown rust.

MATERIALS AND METHODS

The research was conducted in 2017-2020 under artificial inoculation with pathogens in field infectious nurseries of the plant protection department of the V.M. Remeslo Myronivka Institute of Wheat of the National Academy of Agrarian Sciences (Tsentralne village, Obukhiv district, Kyiv Oblast) in the northern part of the Left Bank Forest Steppe.

To fulfil the set purpose, about 200 F_1 hybrids were sown for the 2017 harvest based on resistance against six pathogens and their complex and pests. In 2018, records were made of damage caused by pathogens of the main diseases of leaves, ears of corn, root rots, and pest infestation of F_2 hybrids. Forms resistant to certain diseases were selected, which were inhabited to a lesser extent by pests. For the 2019 harvest, 200 F_3 hybrids were sown on separate infectious backgrounds to carry out selections resistant to both individual diseases and their complex and pest infestation. In the F_3 winter wheat hybrid nursery, 108 hybrid populations were investigated for resistance to leaf diseases and 96 – for resistance to ear and root rot diseases.

In the tube emergence phase, winter wheat plants were infected with spores of the causative agent of brown rust according to the method of E.E. Geschele [4]. To create an artificial infectious background, a synthetic population of the pathogen obtained from the Institute of Plant Protection of the National Academy of Agrarian Sciences was used, and the susceptible variety Myronivska 10 was used as an infection reservoir. To create an artificial infectious background of powdery mildew, a provocative background of the pathogen was created using a local population according to the generally accepted method [22]. The American variety Keprock was used as an infection accumulator.

To investigate the dynamics of disease growth, the assessment during the period of maximum development of the disease was considered as the basis. For powdery mildew, brown rust – the phase of milk ripeness [23; 24]. Using the method of mowing with an entomological net, small mobile insects – leafhoppers, thrips, aphids, adults of cereal flies and sawflies were detected on winter wheat crops. In one field, depending on its size and the number of detected insects, 50-100 sweeps of the net were made in 5 or 10 places of the field. To calculate the number of pests per unit area, two sweeps were conventionally equated to an area of 1 m^2 [24; 25]. The pests that feed on the surface of plants (bugs, bread bugs, leeches, etc.) were counted both directly on the plants and after shaking them off the plants into an entomological net [24-26].

To figure out the influence of weather conditions during the years of research, namely temperature and precipitation, on the development and spread of diseases, the calculation of the hydrothermal coefficient (HTC) was used [27]. The autumn of 2015-2019 was characterized by generally unfavourable weather conditions for the development of diseases and pests on winter wheat, as the lack of rain and high temperatures led to a delay in germination. In turn, the absence of pathogens and minimal infestation by pests was noted on the late seedlings of winter wheat. In 2016, during the period of recovery of spring vegetation – full maturity of winter wheat (HTC 1.5) as a result of optimal moisture, the development, and growth of pathogens and moderate pest infestation were noted (Fig. 1). In 2017, in the same period (HTC 0.8), drier weather conditions were noted, which limited the development of the main pathogens, moderate plant infestation by pests, and a complete absence of damage to plants by septoriosis of leaves and brown rust. In the same year, a considerable development of the hard soot of the wheat ear was noted, which in some varieties reached 50.0%.

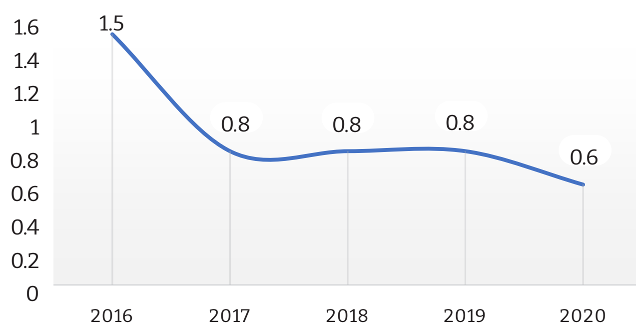

Figure 1. Indicators of HTC during the years of research

In 2018, the weather conditions were also not very conducive to the development of leaf diseases due to the abnormally dry conditions of the winter wheat growing season, as the temperature was unusually high almost every month. Precipitation in the 3rd decade of June resumed the growth of leaf septoriosis and brown rust. In 2020, starting from the recovery of spring vegetation and until the full maturity of winter wheat varieties, the weather conditions contributed to the partial development of foliar diseases. As a result of the cool and dry weather in the first decade of June, the development of powdery mildew stopped and damage to plants did not exceed 0-15.0%. The development of hard soot, root rot, and fusarium head blight was 50.0, 31.3 and 7.5%, respectively.

RESULTS AND DISCUSSION

In the F_3 hybrid nursery, on separate artificial infectious backgrounds, records were made of plant damage by powdery mildew, leaf septoria, fusarium wilt and hard ear smut, brown rust, and infestation by pests. Disease-resistant forms, less prone to colonisation by pests, were selected. Against the provocative background of powdery mildew (Fig. 2), 246 selections were selected and analysed. Highly resistant against the pathogen (up to 5%) were the combinations created with the following resistance sources: Zdar, Fakon, Pi170911, Bongo – Svitanok Myronivskyi/Zdar, Kolos Myronivshchyny/Fakon, Berehynia Myronivska/Pi170911, Dostatok/Bongo. Their population with thrips larvae varied from 5.2 to 14.5 spec/ear (Economic damage threshold or EDT 20.0-30.0 spec/m^2), and leeches – 5.0-18.0 spec/m^2 (EDT 150.0-200.0 spec/m^2). Resistance against the pathogen (up to 10.0%) was observed in two crossing combinations (Horlytsia Myronivska/Gloria and Remeslivna/Wervok).

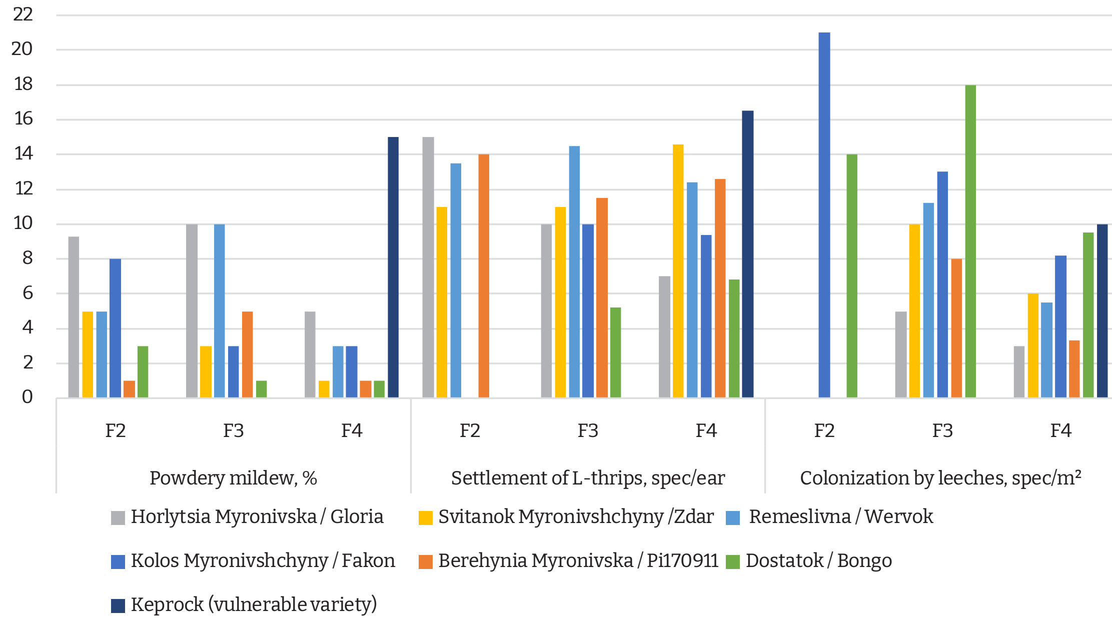

Figure 2. Complex resistance of the best F_2-F_4 hybrids of soft winter wheat against powdery mildew pathogens and pests (2018-2020)

On the artificial infectious background of hybrids of the third generation, 280 selections were selected and analysed for resistance to brown rust (Fig. 3). The largest number of resistant offspring was obtained in crossing combinations created with the following resistance sources: Flex, V 1275, Tobarzo, 203-238. It is worth noting the hybrids: Oberih Myronivskyi/Flex, Smuhlianka/V 1275, Monotyp/Tobarzo, Kolos Myronivshchyna/203-238. Damage to winter wheat plants by the causative agent of brown rust was observed within 3.0-10.0%. These combinations were also distinguished by a small population of pests (thrips larvae and leeches), and it was below the harmfulness threshold.

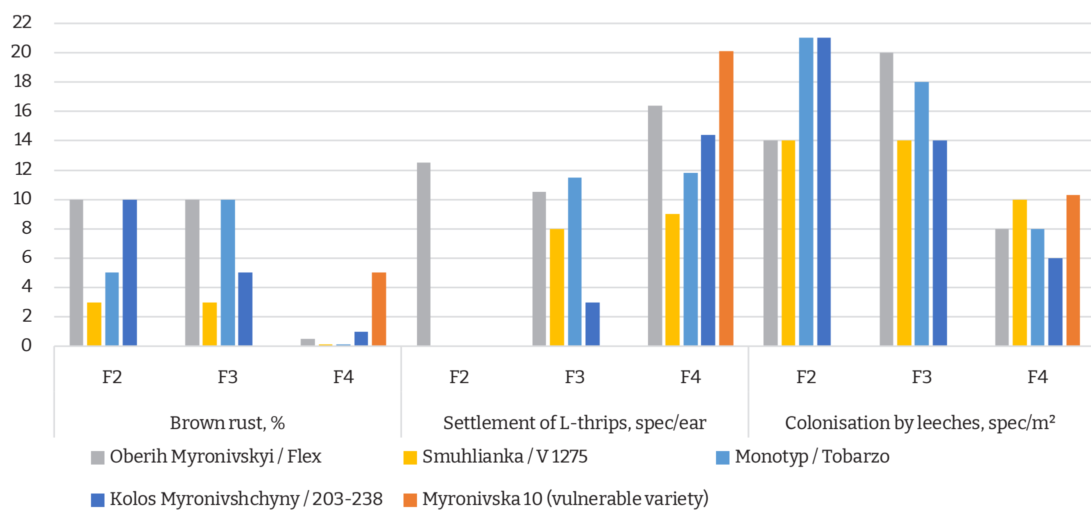

Figure 3. Complex resistance of the best F_2-F_4 hybrids of soft winter wheat against brown rust pathogens and pests (2018-2020)

In the hybrid nursery of the fourth generation, 96 hybrid populations were investigated for resistance to leaf diseases and 126 – for resistance to ear and root rot diseases. On separate artificial infectious backgrounds, records were made of damage caused by pathogens of the main diseases and the colonization of plants by pests. Disease-resistant forms that were less colonized by pests were selected. Against the provocative background of powdery mildew, 200 selections were selected and analysed. Highly resistant (up to 5%) against the pathogen of powdery mildew were the combinations created with the following resistance sources: Zdar, Fakon, Pi170911, Bongo – Svitanok Myronivskyi/Zdar, Kolos Myronivshchyny/Fakon, Berehynia Myronivska/Pi170911, Dostatok/Bongo (Fig. 2). Their population with thrips larvae varied from 6.8 to 14.6 spec/ear (EDT 20.0-30.0 spec/ear), and leeches – 3.0-9.5 copies/m^2 (EDT 150.0-200.0 spec/m^2).

On the artificial infectious background of hybrids of the fourth generation, 215 selections were selected and analysed for resistance to brown rust. The largest number of resistant offspring (see Fig. 3) was obtained in crossing combinations created with the participation of sources of resistance: Flex, V 1275, Tobarzo, 203-238. It is worth noting the hybrids: Oberig Myronivskyi/Flex, Smuglyanka/V 1275, Monotype/Tobarzo, Kolos Myronivshchyna/203-238. Damage to winter wheat plants by the causative agent of brown rust was not high. Only the first manifestation of the disease was observed in up to 1.0% (single pustules). These combinations were also distinguished by the small population of pests (thrips larvae (9.0-16.4 spec/ear) and leeches (6.0-10.0 spec/m^2) and it was below the EDT – 20.0-30.0 spec/ear of thrips larvae and 150.0-200.0 spec/m^2 of leech on winter wheat.

Plant height of F_3 hybrids did not differ substantially from the parental forms, and spike length, number of spikelets in a spike, and weight of grains from a spike had a noticeable positive difference with the maternal and parental forms. Exceeding ear parameters in hybrid combinations of the third generation of winter and spring wheat were observed in the studies of Ukrainian and foreign scientists. According to research results [28; 29] the inheritance of the soft winter wheat trait "the number of grains from an ear" in seven out of twelve hybrid combinations was according to the type of positive overdominance, in one – according to the type of positive dominance, in two – according to the type of intermediate inheritance; one has negative overdominance.

The selection value of the hybrid combinations created with the Berehynia Myronivska variety, which contains the Lr 34(+) allele, involved in crossbreeding to create the disease-resistant F_4 hybrid material. Valuable forms were selected based on the combination of elements of productivity (length of ear, number of grains in an ear, and mass of grain from an ear) and resistance to powdery mildew in comparison with parental forms (Table 1). The largest number of grains in an ear was obtained in the combination Svitanok Myronivskyi/Zdar (61.5 pcs), and the largest weight of grain from an ear – in the combinations Horlytsia Myronivska/Gloria and Berehynia Myronivska/Pi170911 (2.38 g and 2.37 g, respectively).

Table 1. Elements of productivity of hybrids and parental forms of soft winter wheat resistant to powdery mildew (2019-2020)

Parent forms, hybrid combinations	Plant height, cm		Spike length, cm		Amount of grain in an ear, pcs.		Mass of grains from an ear of corn, g	
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Keprock St (vulnerable variety)	**95.0**	**105.5**	**6.9**	**7.6**	**36.7**	**48.7**	**1.6**	**1.72**
♀ ***Horlytsia Myronivska***	*90*	*90.0*	*7.7*	*7.7*	*41.2*	*41.2*	*1.82*	*1.82*
Horlytsia Myronivska/Gloria	90	91.2	7.9	8.1	53.1	53.3	2.34	2.38
♂ *Gloria*	*108*	*106.1*	*7.9*	*7.9*	*30.4*	*31.4*	*1.09*	*1.12*
♀ *Svitanok Myronivskyi*	*80*	*74.3*	*8.5*	*9.8*	*43.4*	*50.5*	*1.46*	*1. 97*
Svitanok Myronivskyi/Zdar	84	73.5	9.8	11.2	49.5	61.5	1.79	2.08
♂ *Zdar*	*62*	*62.0*	*6.0*	*7.1*	*32.5*	*36.5*	*0.98*	*0.98*
♀ *Remeslivna*	*85*	*81.1*	*8.0*	*9.5*	*40.7*	*40.7*	*1.36*	*1.48*
Remeslivna/Werwok	70	82.5	10.0	11.6	48.4	59.2	2.06	2.23
♂ *Werwok*	*90*	*86.0*	*8.7*	*8.9*	*40.1*	*41.4*	*1.62*	*1.68*
♀ *Kolos Myronivshchyny*	*105*	*103*	*7.8*	*8.8*	*42.8*	*49.7*	*1.66*	*1.96*
Kolos Myrnoivshchyny/Fakon	90	89.5	9.7	9.6	55.7	55.7	2.28	2.28
♂ *Fakon*	*80*	*81.0*	*6.9*	*6.7*	*34.1*	*36.4*	*1.23*	*1.43*
♀ *Berehynia Myronivska*	*95*	*96.0*	*7.3*	*8.3*	*30.5*	*32.5*	*1.27*	*1.36*
Berehynia Myronivska/Pi170911	100	96.5	10.0	9.9	46.0	54.0	2.29	2.37
♂ Pi170911	*85*	*84.0*	*7.0*	*7.8*	*34.2*	*33.4*	*1.41*	*1.53*
♀ *Dostatok*	*100*	*99.8*	*8.1*	*8.6*	*45.7*	*46.4*	*1.80*	*1.88*
Dostatok/Bongo	108	104.2	8.8	9.8	51.1	55.1	1.94	2.06
♂ *Bongo*	*105*	*105.2*	*6.7*	*7.7*	*29.7*	*29.9*	*1.31*	*1.39*
LSD_{05}	**2.2**	**5.9**	**0.5**	**0.5**	**5.1**	**5.9**	**0.22**	**0.26**

Among the F_4 populations, 1,405 selections were selected and analysed on the artificial infectious backgrounds of brown rust, hard soot, fusarium head blight, root rot, and the provoking background of powdery mildew. A structural analysis was carried out on the elements of productivity of the selected selections, which were distinguished by their resistance against the main pathogens and pests. Valuable forms were selected based on the combination of productivity elements (ear length, number of grains in an ear, and weight of grain from an ear) and resistance to brown rust in comparison with parental forms, presented in Table 2. The combination Oberih Myronivskyi/Flex stood out in terms of resistance to brown rust and productivity elements.

Table 2. Performance elements of hybrids and parental forms of soft winter wheat resistant to brown rust (2019-2020)

Parent forms, hybrid combinations	Plant height, cm		Spike length, cm		Amount of grain in an ear, pcs.		Mass of grains from an ear of corn, g	
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Myronivska 10 St (vulnerable variety)	**115**	**98.4**	**7.5**	**8.6**	**33.8**	**43.3**	**1.42**	**1.66**
♀ *Oberih Myronivskyi*	*95*	*95.9*	*6.6*	*7.8*	*26.2*	*39.2*	*1.19*	*1.46*
Oberih Myronivskyi/Flex	95	80.0	8.4	10.1	41.5	57.2	2.02	2.36
♂ *Flex*	*120*	*98.2*	*6.0*	*6.8*	*30.3*	*42.3*	*1.01*	*1.19*
♀ *Kolos Myronivshchyny*	*105*	*70.5*	*7.8*	*7.8*	*42.8*	*43.6*	*1.66*	*1.68*
Kolo Myronivshchyny/203-238	105	68.1	6.8	7.5	34.8	55.4	1.69	2.05
♂ *203-238*	*100*	*67.5*	*6.4*	*6.9*	*39.5*	*40.5*	*1.64*	*1.69*
♀ *Monotyp*	*92*	*92.6*	*8.0*	*8.1*	*48.8*	*48.3*	*1.69*	*1.78*
Monotyp/Tobarzo	100	86.5	8.0	8.3	50.7	49.2	2.12	2.09
♂ *Tobarzo*	*100*	*86.1*	*6.1*	*7.1*	*38.7*	*38.4*	*1.54*	*1.64*
♀ *Smuhlianka*	*85*	*85.3*	*7.6*	*7.8*	*30.5*	*31.7*	*1.26*	*1.36*
Smuhlianka/ V1275	85	84.5	9.1	10.2	38.8	56.1	1.67	2.16
♂ *V1275*	*85*	*84.2*	*6.4*	*7.2*	*30.5*	*31.5*	*1.04*	*1.00*
LSD_{05}	**2.3**	**5.7**	**0.6**	**0.6**	**5.4**	**6.0**	**0.25**	**0.28**

According to the indicator, the height of the F_4 hybrid plants, which stood out for their resistance to diseases of the ear and root rot, did not differ substantially from the parental forms, and the length of the ear, the number of spikes in the ear, and the mass of grains from the ear had a noticeable positive difference between the maternal and parental forms. The combination of signs of complex resistance against foliar and root diseases with an increase in the height and productivity of the ear in hybrid combinations of the fourth generation of winter and spring wheat was noted in the studies of Ukrainian and foreign scientists. It is worth noting the results of research by Srinivasachary, N. Gosman *et al.* [30], who, using the example of winter wheat, conducted a study of the relationship between the genes of semi-dwarfism and susceptibility of the variety to fusarium head blight. The data obtained by them indicate that the highest value for selection for complex resistance to diseases has the forms that were selected based on a set of traits in years with a strong development of the disease. Furthermore, they proved the possibility of combining disease resistance with high productivity and grain quality in one variety.

The complete dominance and transmission of disease-resistant maternal traits in the majority (78-84%) of the first-generation hybrids was noted in the studies of S.V. Retman [31] upon crossbreeding short-growing Western European wheats resistant to fungal diseases with unstable varieties of domestic selection in different years. In their studies of the development and distribution in the United States and Canada in 1991-1996 of the epiphytotia of Fusarium head blight of wheat and barley, M. McMullen *et al.* [32] established that during splitting in the F_2-F_4 generation, plants with different degrees of damage were found – from 1-5% to 50-60%. For further selection work, scientists selected only resistant and medium-resistant promising forms of wheat and barley, which in the F_4-F_6 generations were involved in crossbreeding with highly winter-resistant productive varieties and lines of local selection to transfer genes for resistance to fusarium wilt to them.

According to the results of the study of constant lines of winter wheat, 11 disease-resistant lines were transferred from the selection nursery to the National Centre of Plant Genetic Resources of Ukraine (V.Ya. Yuryev Institute of Crop Production, Kharkiv) in 2018, and 9 in 2019. The obtained initial selection material, which stood out for its resistance to diseases and pests (Table 3), was transferred to the winter wheat selection laboratory for further use in the selection.

Table 3. Immunological characteristics of winter wheat lines in terms of resistance against pathogens of foliar diseases submitted to the National Agricultural Research Service of Ukraine (2020)

Line	Pedigree	Vulnerability, %		
		With powdery mildew	With leaf septoria	With brown rust
Powdery mildew				
Keprock	**Vulnerable variety**	**15.0**	**25.0**	**1.0**
Lutescens E.g.484/18	P.i. 170911/ Yuviliar Myronivskyi	5.0	10.0	0.5
Lutescens E.g.485/18	Snihurka/Selidon	3.0	10.0	0.1
Brown rust				
Myronivska 10	**Vulnerable variety**	**10.0**	**20.0**	**5.0**
Erythrospermum P.r.141/18	(TAM-200 x Myrlena) x Myrlena	5.0	8.0	0.1
Erythrospermum P.r.142/18	(Matyo x Kalynova) x Kalynova	1.0	10.0	0
Erythrospermum P.r.144/18	TAM-200 x Myrlena	5.0	10.0	0
Lutescens P.r.145/18	Kolos Myrnoivshchyny x Warwick	5.0	10.0	0.1
Erythrospermum P.r.146/18	Ekonomka x Tsarivna	8.0	10.0	0
Lutescens P.r.147/18	Beres x Myronivska 65	3.0	3.0	0.1

In 2020, certificates were received for two samples under the winter wheat breeding program for resistance to brown rust – Erythrospermum 141-18 and Erythrospermum 146-18 lines, in which TAM 200 and Ekonomka resistance sources were used as mother forms. They were assigned National Catalogue numbers UA0123473 and UA0123470, respectively, for a combination of high group resistance to powdery mildew, brown leaf rust, snow mould (score 9), and leaf septoria.

CONCLUSIONS

The results of the conducted study indicate the possibility of using resistant varieties of winter wheat as a means of restraining the growth of infection by pathogens without chemical protection agents. Highly resistant (up to 5%) F_4 hybrids against powdery mildew were selected as follows: Svitanok Myronivskyi/Zdar, Kolos Myronivshchyny/Fakon, Berehynia Myronivska/Pi170911, Dostatok/Bongo, which were created with resistance sources Zdar, Fakon, Pi170911, Bongo, and are characterized by complex resistance to their settlement with thrips larvae, the number of which varied within 6.8-14.6 spec/ear (EDT 20.0-30.0 spec/ear) and leeches – 3.0-9.5 spec/m^2 (EDT 150.0-200.0 spec/m^2). Based on the combination of elements of productivity (length of ear, number of grains in an ear, and weight of grain from an ear) and resistance to powdery mildew, the combination Svitanok Myronivskyi/Zdar with the largest number of grains in an ear (61.5 pcs.) was selected.

Selected combinations of crossing F_4, which are characterized by resistance to brown rust and a small population of pests (thrips larvae 9.0-16.4 spec/ear with EDT 20.0-30.0 spec/ear and leech 6.0-10.0 spec/m^2 with EDT 150.0-200.0 spec/m^2): Oberih Myronivskyi/Flex, Smuhlianka/V 1275, Monotyp/Tobarzo, Kolos Myronivshchyna/203-238. The Oberih Myronivskyi/Flex combination is highlighted for its resistance to brown rust and performance elements.

Selected sources of resistance are used to create selection material with comprehensive resistance to foliar diseases and valuable economic traits. 220 genotypes were transferred to the winter wheat selection laboratory of the V.M. Remeslo Myronivka Institute of Wheat of NAAS of Ukraine from the selection nursery. Apart from group resistance to diseases, these genotypes are characterized by high productivity and quality of the grown products, have a wide further use in the selection.

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Створення високопродуктивних форм пшениці озимої з комплексною стійкістю проти хвороб та шкідників на штучних інфекційних фонах їх збудників

Анотація. Хвороби польових культур суттєво знижують врожайність та якість отриманої сільськогосподарської продукції. Недобір валового збору зерна за рахунок хвороб та шкідників щорічно може досягати близько 25-30 % тому створення стійких сортів є актуальним завданням в селекції пшениці озимої. Мета досліджень полягала у створенні нового високопродуктивного селекційного матеріалу з комплексною стійкістю проти основних найбільш шкідливих хвороб для подальшого використання в селекційному процесі пшениці озимої. У фазі виходу рослин в трубку проводили *інфікування* рослин пшениці озимої спорами збудника бурої іржі за методикою Е.Е. Гешеле. З метою створення штучного інфекційного фону бурої іржі використовували синтетичну популяцію збудника (Інститут захисту рослин НААН), як накопичувач інфекції – сприйнятливий сорт Миронівська 10. Для створення штучного інфекційного фону борошнистої роси використовуючи місцеву популяцію та накопичувач інфекції американський сорт Кепрок. У гібридному розсаднику F_3 на провокуючому фоні борошнистої роси відібрано високостійкі проти збудника (до 5 %) комбінації, створені за участю джерел стійкості: Zdar, Fakon, Pi170911, Bongo – Світанок Миронівський/Zdar, Колос Миронівщини/Fakon, Берегиня Миронівська/Pi170911, Достаток/Bongo. Стійкість проти патогена (до 10,0 %) спостерігали у двох комбінацій схрещування (Горлиця миронівська/Gloria та Ремеслівна/Wervok). На штучному інфекційному фоні гібридів четвертого покоління за стійкістю проти бурої іржі відібрано комбінації схрещування, створені за участі джерел стійкості: Flex, V 1275, Tobarzo, 203-238. Варто зазначити гібриди: Оберіг Миронівський/Flex, Смуглянка/V 1275, Монотип/Tobarzo, Колос Миронівщини/203-238. Найбільшу кількість зерен у колосі отримано у комбінації Світанок Миронівський/Zdar (61,5 шт.), а найбільша маса зерна з колоса у комбінацій Горлиця Миронівська/Gloria та Берегиня миронівська/Pi170911 (2,38 г та 2,37 г відповідно). За стійкістю проти бурої іржі та елементами продуктивності виокремилась комбінація Оберіг Миронівський/Flex. Виділені за результатами проведених досліджень зразки використовуються в якості цінного вихідного матеріалу для створення нових сортів пшениці озимої стійких до хвороб у Лісостепу України

Ключові слова: *Triticum aestivum* L., вихідний матеріал, джерела стійкості, збудники хвороб, борошниста роса, бура іржа, сорт