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RESISTANCE OF WINTER RYE SAMPLES TO BROWN LEAF RUST AND STEM RUST

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Topicality. *Developing high-productivity varieties with resistance to lodging and diseases, and adverse environmental conditions, improving a number of other indicators is the task of modern plant breeding. Solving the problem of rust resistance of winter rye, as an important grain crop, is quite relevant.* ***Purpose.*** *Studying the resistance of winter rye varieties, hybrids and lines to brown leaf rust and stem rust in the conditions of the Right-Bank Forest-Steppe of Ukraine.* ***Materials and Methods.*** *The research was carried out at the Verkhniachka Research and Breeding Station of the Institute of Bioenergy Crops and Sugar Beet of NAAS during 2020–2023. The material of the study was crops of 58 collection winter rye samples. We carried out route surveys of crops, determined the spread of diseases in the maximum disease development stage using generally accepted methods.* ***Results.*** *According to the degree of resistance to brown leaf rust, 58 (immune) samples were found as follows: 1 (1.7 %) was very highly resistant, 19 (32.8 %) were characterised as highly resistant, 21 (36.2 %) as resistant and 17 (29.3 %) as moderately susceptible. According to the degree of resistance (susceptibility) to stem rust, 14 (24.1 %) hybrid combinations were characterised as immune, 24 (41.4 %) as highly resistant, 9 (15.5 %) as resistant, and 11 (19.0 %) as slightly susceptible. Significantly high yields were recorded in eleven F_1 hybrids: Khlibna Nyva (7.7 t/ha), Volonter (7.1 t/ha), Fiol.F_3 (7.0 t/ha), D/S-7 and I-99/(X-55/Pallada) (6.9 t/ha), Fiol.lus.F_3 (8.0 t/ha), line Palazzo (6.7 t/ha), line Utino (7.1 t/ha), Vetvitske/22 line (6.8 t/ha), I-95/(B/P)(B/P) (6.9 t/ha), R-5/22 (8.4 t/ha) line. It was found that the test weight varied insignificantly from 634 g to 711 g, and the 1000 grain weight ranged from 30.0 g to 44.0 g.* ***Conclusions.*** *A comparative assessment of varieties and hybrids of winter rye to brown leaf rust and stem rust was carried out. The average yield was 5.9 t/ha in the experiment. The yields of eleven (18.9 %) experimental hybrids, i.e. the studied crossing combinations, were high and ranged from 6.7–8.4 t/ha.*

Key words: *winter rye, brown rust, hybrids, lines, resistance, damage*

Introduction. Winter rye is the second most important crop after wheat in our country, the food value of which is determined by the high content of proteins (12.8 %) and carbohydrates (69.1 %) in the grain. The availability of complete proteins enriched with essential amino acids (lysine, arginine), a large amount of easily digestible carbohydrates, essential vitamins (A_1, B_1, B_2, B_3, B_6, PP, C), and a high calorie value (1 kg of rye bread provides 2,481.2 kcal) indicate that rye bread is a highly nutritious food product.

Rye production has always been characterised by unstable yields and gross grain harvests due to growing conditions. Yield losses caused by rust diseases are also significant. The introduction of resistant rye varieties into crop production is one of the safest way to plant protection with the advantages of resource saving, payback, environmental friendliness and manufacturability [1, 2]. In order to minimise yield losses, it is not only a matter of developing high-yielding varieties, but also varieties that are resistant to abiotic stress and pests [3]. One of the main sources of productivity, adaptability and resistance to unfavourable growing conditions is the world collection of winter rye. Therefore, the targeted use and conservation of plant genetic diversity is extremely important for the development of new varieties based on gene pool samples, which ensures increased yields, stabilisation of crop production, and satisfaction of the constantly growing food needs of the population [4–8].

The research was aimed at studying the resistance of winter rye varieties, hybrids and lines

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to brown leaf rust and stem rust in the conditions of the Right-Bank Forest-Steppe of Ukraine.

Materials and Methods. The research was carried out at the Verkhniachka Research and Breeding Station of the Institute of Bioenergy Crops and Sugar Beet of NAAS of Ukraine. The results of studies by the Plant Protection Department on the phytosanitary condition of crops and data of the Khrystynivka meteorological station were used to complete the task. The material was 58 collection varieties of winter rye. As a standard, we used the zoned variety Vals of our own selection, which had an average yield of 5.9 t/ha. The winter rye varieties were sown after peas in the second or third ten days of September. The size of the experimental plots was 10 m^2, with a six-fold repetition of an experiment. The cultivation technology was generally accepted for the region. Route ins-pections of crops were carried out, with a visual assessment of the damage to the flag and subflag leaves of plants. To determine the intensity of plant damage by the pathogen, we used the Mains-Jackson scale and an integrated nine-point scale for assessing resistance to brown rust [9, 10].

Modified scale for assessing the winter rye resistance to brown rust by the infection level and type of plant response

Scale of infection		Score and degree of resistance	
0	No infection	9	Very highly resistant
1–5 %	Weak infection	8	Highly resistant
6–10 і 11–15 %	Typical spots	7–6	Resistant
16–25 %	Typical spots	5	Moderately susceptible
26–40 і 41–65 %	Typical spots	4–3	Susceptible
66–90 %	Heavy infection	2	Highly susceptible
91–100 %	Very heavy infection	1	Very highly susceptible
nType of plant response		9 – Immune	
		8 – Highly resistant	
		7 – Resistant	
		5 – Moderately susceptible	
		3 – Susceptible	

The intensity of the disease development is determined by weather conditions in the spring and summer growing season. The springs of the studied years were moderately warm. The average daily air temperatures in March was +2.0 °C in 2021 and 2022, and +5.1 °C in 2023, which was 2.3 and 5.4 °C higher than the long-term average (Table 1).

Table 1. Weather conditions in the spring and summer growing season (2021–2023)

Month	Precipitation, mm				Air temperature, °C			
	2020–2021	2021–2022	2022–2023	average	2020–2021	2021–2022	2022–2023	average
March	34.9	15.2	48.6	26	2.0	2.0	5.1	-0.3
April	58.3	78.4	151.9	35	7.4	8.6	8.8	7.3
May	80.2	25.2	24.2	50	14.0	14.5	15.4	14.1
June	165.5	38.9	40.5	66	19.8	20.5	19.6	17.1
July	44.7	28.5	101.7	59	23.2	21.0	21.3	19.3

In April, the average daily air temperature was +7.4, +8.6 and +8.8 °C, with precipitation of 58.3, 78.4 and 151.9 mm, compared to the long-term average of 35.0 mm. Weather conditions contributed to the gradual growth resumpnorm) and moderate in 2022 and 2023 (50.4 % and 48.4 %, respectively), while the lack of precipitation did not affect the growth of the crop's tion of winter rye. In May, the temperature was within the long-term average, the maximum temperature reached +28.0°C, and the minimum temperature was not lower than 1.4°C. In terms of precipitation, 2021 was wet (160.4 % of the vegetative mass.

In summer, the air temperature was above the long-term average. June was hot, with ave-

rage daily temperatures ranging from +19.6 to +20.5 °C, which is 2.5-3.4 °C above normal, and precipitation of 165.5, 38.9 and 40.5 mm by year. Under such weather conditions, the first symptoms of the disease began to appear, covering up to 20 % of the area under crop.

July was hot with insufficient precipitation of 44.7 and 28.5 mm in 2021 and 2022, respectively, but in 2023, there was 101.7 mm, or 172.4 % of the long-term average. The average temperature was 0.7–3.9 °C above normal. Frequent precipitation in June 2021 and July 2023 caused localised lodging of crops and massive disease infection of plants of the crop.

Results and Discussion. Monitoring of winter rye crops in the experimental field during the years under study showed that the crop was affected by rust annually.

The causative agent of brown rust is the dioecious basidiomycete *Puccinia dispersa Erirss* et Henn., which has a high reproductive capacity - the duration of urediniogenesis at 10 °C is 12 days, and at 20 °C – 5 days. Urediniospores require drip water and a temperature of 0 to 30 °C (optimum 10–20 °C) for germination. Brown rust reduces the assimilation surface, winter hardiness and productivity of rye plants. Yield loss can exceed 20 %.

The first symptoms of the disease appear on the leaves, sheaths and spikelet scales as small, numerous orange, brown or reddish pustules (uredinia) with uredospores. They subsequently turn into teli with teliospores and acquire a black tint. Uredinia and telia are randomly located on the upper (sometimes lower) side of the leaf. According to the resistance (susceptibility) level to brown leaf rust the following varieties were identified among 58 (immune) varieties: 1 (1.7 %) was very highly resistant, 19 (32.8 %) were characterised as highly resistant, 21 (36.2 %) were resistant and 17 (29.3 %) were moderately susceptible. According to the level of resistance to stem rust, 14 (24.1 %) hybrid combinations were characterised as immune, 24 (41.4 %) as highly resistant, 9 (15.5 %) as resistant, and 11 (19.0 %) as moderately susceptible.

The main requirement of crop production for a variety is high productivity in a wide range of environmental conditions to confirm the superiority of new varieties over old ones.

The high yield of the best hybrids depends on both genotype and their interaction with environmental conditions. Eleven experimental hybrids F_1 had significantly high yields, such as Khlibna Nyva, Volonter, D/S-7 and I-99/(X-55/Pallada), Fiol.F_3, Fiol.lus.F_3, Palazzo line, Utino line, Vetvitske/22 line, I-95/(B/P)(B/P), P-5/22 line, which represent 18.9 % of all studied hybrid combinations. The yield ranged from 6.7–8.4 t/ha (Table 2).

The most important indicator of winter rye grain quality is test weight, which characterises the degree of grain filling and ripening. According to the State Standard (DSTU 10840:2019 Grain. Method of determining the test weight), this indicator should be at least 700 g/l, but among the presented varieties and lines, only 1 variety ex-

Table 2. Yield and infection of the most promising winter rye hybrids in 2020–2023

Hybrid	Yield, t/ha	Test weight, g/l	1000 grain weight, g	Infection of rye plants, points	
				Brown rust	Stem rust
Khlibna Nyva	7.7	701	30.0	7	8
Volonter	7.1	663	30.0	8	8
D/S-7	6.9	711	44.0	7	8
I-99/(X-55/Pallada)	6.9	677	34.0	8	8
Fiol.F_3	7.0	676	36.0	8	7
Fiol.lus.F_3	8.0	678	40.0	8	8
Palazzo line	6.7	678	37.0	8	8
Utino line	7.1	678	35.0	7	8
Vetvitske/22 line	6.8	667	44.0	8	8
I-95/(B/P)(B/P)	6.9	680	43.0	9	8
P-5/22	8.4	634	38.0	7	8
Vals standard	5.9	670	40.0	8	8

ceeded this value. In other samples, the test grain ranged from 634 to 701 g.

The 1000 grain weight is a genetically determined index and therefore, it varies within a fairly narrow range, regardless of external factors. There were 2 varieties D/S-7 and I-95/(B/P)(B/P) and 1 Vetvitske/22 line with high 1000 grain weight exceeding the Vals standard, with values of 44.0 g, 43.0 g and 44.0 g, respectively. The rest of the samples had values in the range of 30.0–40.0 g.

Conclusions. It is proved that the development of brown rust depends on the meteorological conditions prevailing during the growing season. A comparative assessment of the resistance of winter rye varieties and hybrids to brown leaf and stem rust was carried out. Among the studied hybrids, the highest yields were formed by hybrids on a fertile and sterile basis: l R-5/22 (8.4 t/ha), Fiol.lus.F3 (8.0 t/ha), Vals and Khlibna Nyva (7.7 t/ha each), Volonter and Utino line (7.1 t/ha each). We recommend involving these varieties in the breeding process to develop competitive seed material.

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Актуальність. Створення сортів з високою продуктивністю, стійких до полягання і хвороб, несприятливих умов середовища, поліпшення ряду інших показників – завдання сучасної селекції. Озиме жито – важлива зернова культура, тому розв'язання проблеми стійкості проти іржі є досить актуальним. **Мета роботи.** Вивчення стійкості сортів, гібридів та ліній жита озимого проти бурої листкової та стеблової лінійної іржі в умовах Правобережного Лісостепу України. **Матеріали та методи досліджень.** Дослідження проводились на Верхняцькій дослідно-селекційній станції Інституту біоенергетичних культур і цукрових буряків НААН протягом 2020–2023 рр. Матеріалом були посіви 58 колекційних сортозразків жита озимого. Провадили маршрутні обстеження посівів, визначали ураже-

ність рослин хворобами у фазу максимального розвитку хвороб за загальноприйнятими методиками. **Результати.** За ступенем стійкості до ураження іржею бурою листковою 58 (імунних) сортозразків виявилися: 1 (1,7 %) – дуже високостійкий, 19 (32,8 %) характеризувалися як високостійкі, 21 (36,2 %) – стійкі та 17 (29,3 %) – помірносприйнятливі. За ступенем стійкості (сприйнятливості) до ураження іржею стебловою лінійною 14 (24,1 %) гібридних комбінацій характеризувалися як імунні, 24 (41,4 %) – високостійкі, 9 (15,5 %) – стійкі, 11 (19,0 %) – слабкосприйнятливі. Істотно високими показниками врожайності характеризувалися одинадцять гібридів F_1: Хлібна Нива (7,7 т/га), Волонтер (7,1 т/га), Фіол.F_3 (7,0 т/га), D/S-7 та І-99/(Х-55/Паллада) (6,9 т/га), Фіол.лус.F_3 (8,0 т/га), л. Palasso (6,7 т/га), л. Utino (7,1 т/га), л. Ветвіцьке/22 (6,8 т/га), І-95/(Б/П)(Б/П) (6,9 т/га), л. Р-5/22 (8,4 т/га). Виявлено, що натура зерна неістотно коливалася в межах від 634 г до 711 г, вага 1000 зерен – від 30,0 г до 44,0 г. **Висновки.** Проведена порівняльна оцінка сортів і гібридів жита озимого до ураження іржею бурою листковою і стебловою лінійною. Середня врожайність в досліді становила 5,9 т/га. Врожайність 11 (18,9 %) експериментальних гібридів, тобто досліджуваних комбінацій схрещування, була висока і коливалася в межах 6,7–8,4 т/га.

Ключові слова: *жито озиме, іржа бура, гібриди, лінії, стійкість, ураження*