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*ORIGINAL ARTICLE*

# Prognosis of the harmfulness of barley rust

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The dynamics of distribution and development of barley spring rust were studied. The maximum spread of the disease ranged from 21.75 % to 30.0 % over the years of research, with intensity from 13.25 % to 19.0 %, respectively. The influence of the disease on the indicators of the structural elements of the spring barley harvest is noted. A close correlation was established between them (r = 0.973, r = 0.980 and r = 0.973). Prognostic models of crop yield losses from rust have been developed. It is possible to predict the loss of spring barley harvest from the disease according to the regression equations Y = 0,169X + 1,224; Y = 1.77X + 23.38 and Y = 1.73X + 26.48.
**Keywords**: spring barley, rust, close correlation, plant protection, yield, disease development.

## Introduction

Spring barley ranks fourth in the area of cultivation in the world and second in Europe among cereals. It ranks second after wheat in both sown area and gross harvest in Ukraine because of its nutritive, feed, and technical value, high yields, natural plant to environmental conditions, and agrotechnical (Gentosh et al., 2020). The variety of uses of barley for food and feed purposes and as a raw material for the brewing industry determine its importance in the grain balance of the country. Barley grain contains 12 % protein, 64.6 % without nitrogenous substances, 5.5 % fiber, 2.1 % fat, 13 % water, 2.8 % ash (Golyshin et al., 1986; Lisovyj, 1999).

In Ukraine, 3–4 million hectares of spring and 400–500 thousand hectares of winter barley are grown annually (Geshele, 1982). The effectiveness of disease protection can be ensured only with the integrated application of organizational, economic, agronomic, and chemical measures. One of the main ways to reduce environmental pollution by pesticide residues and protect barley from disease is a scientific approach to chemicals.

In recent years, plant diseases have become increasingly important, which reduce the yield and quality of agricultural products and lead to significant economic losses. One of them is rust, which affects plants throughout the growing season. Symptoms appear mainly on the leaves of barley. The causative agent of the disease is the fungus *Puccinia hordenia* Lawrow (Dobrozrakova, 1974; Ishkova et al., 2002). Rust dramatically reduces yields, winter, and drought resistance. The most significant harm is caused by the disease when the disease in crops develops in the spring. Severe damage leads to premature ripening of crops, significant crop shortages, especially with insufficient soil moisture. Almost every year, 20–35 % of the crop is lost from rust. In the years of epiphytes, the yield decreases from 25–30 to 5–6 c/ha. With a substantial degree of damage, the grain is so thin that it falls into the waste (Stepanov, 1975). According to A.E. Chumakov (1964), in the central regions of Ukraine, epiphytes of rust are observed on average once in two years. Less often (once in 3-4 years), they occur in Western Ukraine (Chumakov & Zakharova, 1990).

**The purpose of the research** is to study the harmfulness of spring barley rust and to develop mathematical models for calculating losses in the elements of crop structure and biometric indicators of the crop.

## Material and methods

Experimental studies were conducted in 2017–2019 in the laboratory at the Department of Phytopathology named after V.F. Peresypkin and at the phyto-section located in the fields of the agronomic research station of the National University of Life and Environmental Sciences of Ukraine on barley of the Avatar variety, according to the generally accepted method (Gentosh et al., 2010).

The seeds were sown in the terms recommended for this zone, to a depth of 4–6 cm. Seeds quality was determined according to the method (Kalyuzhny et al., 2002). The sowing was carried out manually. The size of the plots was 4 $m^2$. The sowing rate was 4.0 million seeds per 1 ha. The experiment was repeated four times. A systematic method was chosen to place the scheme of the experimental plots (Gentosh et al., 2017). Types of rust diseases of grain crops are taken into account during filling – milk ripeness of grain. The accounting of rust types was carried out approximately on a specially developed scale (Vasilieva, 1993). A combined scale named after T. D. Strachov was used (Strakhov, 1951). To account for rust diseases in fields up to 100 ha, 20 samples of 10 stems in each are taken, and in larger areas for every 100 ha, an additional two samples (Gentosh et al., 2010). The spread of the disease (the number of affected plants or their organs in percent) and the intensity of the disease in percent was calculated by the formula (Fadeeva & Kuzmicheva,1977):

$$R = \sum (a \times b) \times 100/ N \times K$$

where R – development of the disease, %; ∑(a × b) – the sum of the product of the number of plants per the corresponding point or the point of infection; N – total number of registered plants (healthy and affected); K – the highest score of the accounting scale.
The spread of the disease (the percentage of affected plants or individual organs) is determined by the formula:

$$P = n \times 100/N$$

where P – prevalence of the disease, %; N – the total number of plants in samples; n – number of diseased plants in samples.
The development of model-based forecasting of spring barley loss from rust was carried out using mathematical modeling and correlation analysis (Gentosh et al. 2010).

## Results

To determine the spread of spring barley rust, we conducted surveys of crops of this crop in the fields of NULES of Ukraine "Agronomic Research Station" of Vasylkiv district, Kyiv region during 2017-2019. The spread of rust was revealed almost throughout the whole growing season. We noted the first signs of the disease during the flag leaf forming in the spring barley plant. The spread of the disease in 2017 was 13.0%, in 2018 - 18.5%, and 11.0% in 2019, with the intensity of the disease - 5.5; 9.5 and 3.5%, respectively (Table 1).

**Table 1.** Distribution of spring barley rust (Avatar variety, 2017–2019)

| Year | The period of formation of the flag leaf | | Period of milky wax ripeness | |
|---|---|---|---|---|
| | Spread of the disease, % | Development of the disease, % | Spread of the disease, % | Development of the disease, % |
| 2017 | 13.0 | 5.5 | 25.0 | 16.0 |
| 2018 | 18.5 | 9.5 | 30.0 | 19.0 |
| 2019 | 11.0 | 3.5 | 21.75 | 13.25 |
| Burrows05 | 1.95 | 0.86 | 2.5 | 0.94 |

During the period of milk-wax ripeness in spring barley, the spread of the disease was 25.0 % in 2017, 30.0 % in 2018, and 21.75 % in 2019; the intensity of disease development – 16.0, 19.0, and 13.25 %, respectively. Spring barley rust is a hazardous disease, so the study of its prevalence and harmfulness is essential in developing protection measures. After conducting a structural analysis, a significant effect of the pathogen on the growth and development of spring barley plants was noted. At the increased degree of defeat, biometric indicators became lower. In our studies, the growth and development of spring barley plants slowed down significantly with an increasing degree of their defeat (table 2). With the vigorous development of the disease – 75–100 %, the height of the plant decreased by 9.5–15.0 cm, compared with healthy (79.0 cm).

**Table 2.** Influence of rust damage of spring barley on biometric indicators of plants

| Biometric indicators | Type of immune system | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 3 | 2 | 1 | 0 | $NIR_{05}$ |
| Plant height, cm | 79.0 | 77.5 | 73.0 | 69.5 | 64.0 | 1.03 |
| The length of the colossus, cm | 5.5 | 5.2 | 4.95 | 4.35 | 4.05 | 0.21 |

A close correlation between the degree of damage and stem height (r = 0.985) was found. This dependence is expressed in the regression equation Y = - 3,8X + 65 (Fig. 1).

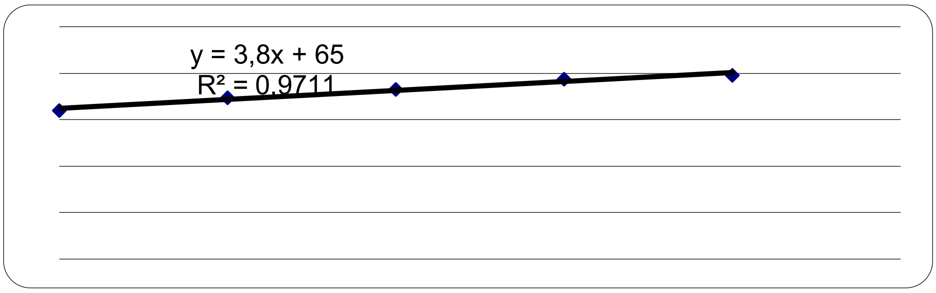


**Fig.1.** Correlation between the type of immunity and the height of the stem of spring barley plants (here and then Avatar variety, VP NULES of Ukraine "Agronomic Research Station" Vasylkiv district, Kyiv region, 2017–2019).

A similar pattern was observed in reducing the length of the spikelet. The development of the disease by 25–50% contributed to a decrease in ear length by 0.3–0.55 cm, respectively, and by 75–100% - by 1.15–1.45 cm compared to healthy plants (5.5 cm.). The correlation coefficient is equal (r = 0.969). The decrease in the length of the ear of spring barley depending on the score of rust is expressed in the regression equation Y = 0.375X + 3.66 (Fig. 2).

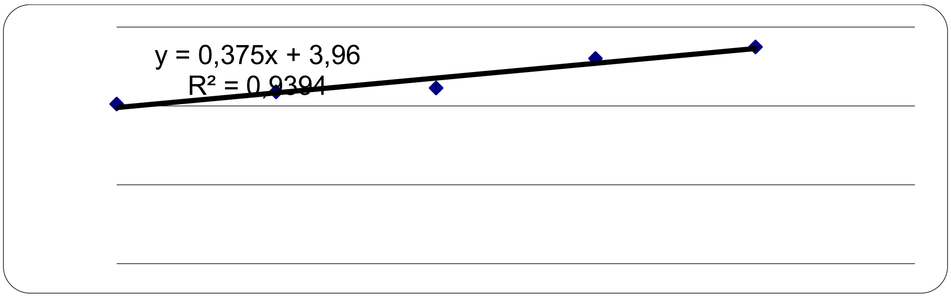


**Fig.2.** Correlation between the type of immunity and the length of spring barley.

Damage to plants by rust significantly affected the elements of the crop structure (table 3). With severe damage (score 0), the plant's weight was 1.29 g, and the weight of 1000 seeds - 23.6 g. In natural plants, these figures were 1.9 and 30.4 g, respectively.

**Table 3.** The impact of damage to spring barley by rust on the elements of the crop structure

| Elements of the crop structure | Type of immune system | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 3 | 2 | 1 | 0 | $NIR_{05}$ |
| Number of seeds from plant, pcs | 32.7 | 32.3 | 30.6 | 27.8 | 26.3 | 1.17 |
| Mass of seeds from the plant, g | 1.9 | 1.79 | 1.51 | 1.32 | 1.29 | 0.25 |
| Weight of 1000 seeds, g | 30.4 | 28.5 | 27.7 | 24.4 | 23.6 | 1.14 |

The relationship between these indicators is closely correlated (r = 0.973, r = 0.980) and is expressed in the regression equations Y = 0.169X + 1.244 (Fig. 3); and Y = 1.77X + 23.38 (Fig. 4).

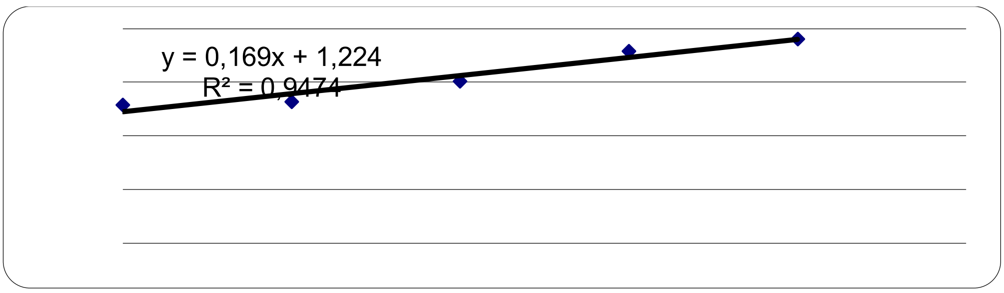


**Fig. 3.** Correlation between the type of immunity and the mass of seeds from the spring barley plant

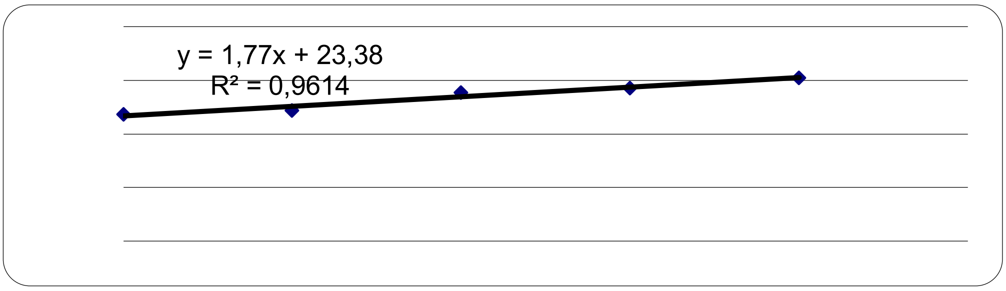


**Fig.4.** Correlation between the type of immunity and the mass of 1000 seeds of spring barley

The most sensitive element of the crop structure that responds to the pathogen is the number of seeds per plant. Thus, with the development of the disease by 25 and 50%, this value decreased by 0.5-2.1 pieces, respectively, and at 75 and 100% - by 4.9 and 6.4 pcs. A close correlation was established between them (r = 0.975), and the dependence is expressed in the regression equation Y = 1.73X + 26.48 (Fig. 5).

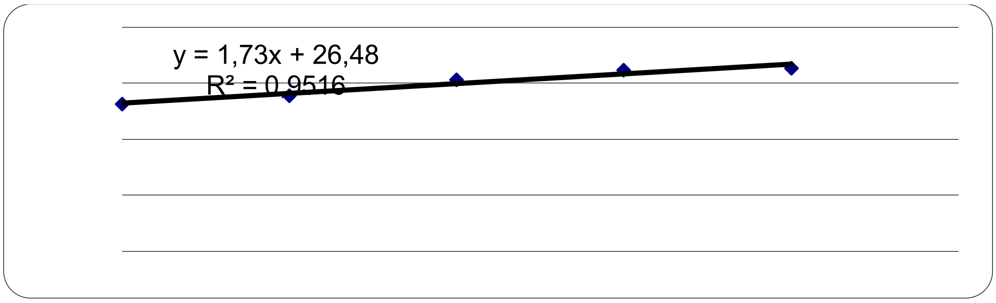


**Fig. 5.** Correlation between the type of immunity and the number of seeds from the spring barley plant

Thus, brown rust of spring barley is widespread in the study area and covers 13.0 % and 18.5 % – during the formation of the flag leaf and 25.0 % and 30.0 % during the milk-wax ripeness of plants. The intensity of their development, in our studies, ranged from 5.5 % to 19.0 %, depending on the phase of development. The disease affected the structure of spring barley yield, so the weight of 1000 seeds in healthy decreased by 1.9–6.8 g compared to healthy plants.

## Conclusions

In the studied area, the rust is widespread throughout the growing season of spring barley and covers from 11.0 % to 18.5 % of plants in the formation of the flag leaf and from 21.75 % to 30.0 % in the period milk-wax ripeness of plants. The intensity of its development, in our studies, ranged from 3.5 % to 19.0 %, depending on the phase of development. We noted a significant effect of the pathogen on the growth and development of spring barley plants. At the increased degree of defeat, biometric indicators became lower. Thus, with an intense lesion (score 0), the plant's weight and the weight of 1000 seeds decreased by 0.61 and 6.8 g, which was 67.9 and 77.6 % of the weight of natural plants indicators were respectively 1.9 and 30.4 g.
A correlation was established between the degree of rust damage and the weight of seeds per plant and 1000 seeds (r = 0.973, r = 0.980), ear length, and the number of seeds per plant (r = 0.969, r = 0.975). The regression equations are calculated, which allow to determine the decrease of these indicator (B) depending on the development of the disease (X) in the phase of flag leaf formation (Y = 0.169X + 1.224, Y = 1.77X + 23.38, Y = 0.375X + 3.66, Y = 1.73X + 26.48).

## References

Bezpal'ko, V.V., Stankevych, S.V., Zhukova, L.V., Zabrodina, I.V., Turenko, V.P., Horyainova, V.V., Poedinceva, A.A., Batova, O.M., Zayarna, O.Yu., Bondarenko, S.V., Dolya, M.M., Mamchur, R.M., Drozd, P.Yu., Sakhnenko, V.V., Matsyura, A.V. (2020). Pre-sowing seed treatment in winter wheat and spring barley cultivation. Ukrainian Journal of Ecology, 10(6), 255–268.

Bezpal'ko, V.V., Zhukova, L.V., Stankevych, S.V., Ogurtsov, Yu.H., Klymenko, I.I., Hutians'kyi, R.A., Fesenko, A.M., Turenko, V.P., Zabrodina, I.V., Bondarenko, S.V., Batova, O.M., Golovan, L.V., Klymenko, I.V., Poedinceva, A.A., Melenti, V.O. (2019). Ecologically safe methods for presowing treatment of cereal seeds. Ukrainian Journal of Ecology, 9(3), 189–197.

Chumakov, A.K. & Zaharova, T.I. (1990). Vredonosnost boleznej selskohozyajstvennyh kultur. Moskwa: Agropromizdat, 122 (in Russian).

Chuprina, Yu.Yu., Klymenko, I.V., Havva, D.V., Golovan, L.V., Buzina, I.M., Titova, A. Ye., Mikheev, V.H., Zabrodina, I.V., Stankevych, S.V. (2020). The level of adaptability of perspective samples of soft and durum spring wheat in Ukrainian forest–steppe. Ukrainian Journal of Ecology, 10(6), 12–22.

Dobrozrakova, T.L. (1974). Selskohozyajstvennaya fitopatologiya, 2-e izd., ispr. i dop. Pod redakciej M.K. Hohryakova. Leningrad, izd. «Kolos», 382 (in Russian).

Fadeev, Yu.N. & Kuzmichev, A.A.(1977). Metody fitopatologicheskih i entomologicheskih issledovanij v selekcii rastenij. Nauch. trudy VASHNIL. Moskwa, Kolos, 185 (in Russian).
Gentosh, D.T. et al. (2010). Korotkostrokovij prognoz sezonnogo poshirennya ta rozvitku korenevih gnilej gorohu za dopomogoyu matematichnogo modelyuvannya. Karantin i zahist roslin, 10, 19–22 (in Ukrainian).
Gentosh, D.T., Kirik, M.M. & Gentosh, I.D. (2017). Shkidlivist korenevih gnilej yachmenyu yarogo. Naukovi dopovidi NUBiP Ukrayini, 4 (68), 7–11 (in Ukrainian).
Gentosh, D.T., Kyryk, M.M., Gentosh, I.D., Pikovskyi, MY., Polozhenets, V.M., Stankevych, S.V., Nemerytska, L.V., Zhuravska, I.A., Zabrodina, I.V., Zhukova, L.V. (2020). Species compositions of root rot agents of spring barley. Ukrainian Journal of Ecology, 10 (3), 106–109.
Geshele, E.E. (1982). Metodicheskoe rukovodstvo po fitopatologicheskoj ocenke zernovyh kultur.Odesa, 78 (in Russian).
Golyshin, N.M., Zaharenko, V.A. & Martynenko, V.I. (1986). Zashita zernovyh kultur pri intensivnyh tehnologiyah. Moskwa, Agroprom-izdat, 160 (in Russian).
Horiainova, V.V., Turenko, V.P., Bilyk, M.O., Stankevych, S.V., Zhukova, L.V., Batova, O.M., Martynenko, V.I., Kucherenko, Ye.Yu., Zviahintseva, A.M. (2020). Species composition, morphological and biological peculiarities of leaf pathogens of spring wheat. Ukrainian Journal of Ecology, 10(3), 115–120.
Ishkova, T.I., Berestecka, L.I. & Gasich, E.L. (2002). Diagnostika osnovnih gribnih hvorob zernovih kultur. Sankt-Peterburg, 76 (in Russian).
Kalyuzhnij, Yu.V., Markov, I.L. & Zibcev, V.M. (2002). Metodichni rekomendaciyi do navchalnoyi praktiki z silsko-gospodarskoyi fitopatologiyi dlya studentiv fakultetu zahistu roslin. Kyiv: Nau, 42(in Russian).
Lisovyj, M.P. (1999). Dovidnik z zahistu roslin. Kyiv, Urozhaj, 744 (in Ukrainian).
Omelyuta, V.P. (1986). Oblik shkidnikiv i hvorob silskogospodarskih kultur. Kyiv, Urozhaj, 296 (in Ukrainian).
Stepanov, K.M. (1975). Irzha zernovih kultur. Leningrad, Kolos, 75 (in Ukrainian).
Strahov, T.D. (1951). Ocinka sortiv pshenici po imunnosti i urazhennyu buroyu listkovoyu irzheyu, 8–12 (in Ukrainian).
Turenko, V.P., Bilyk, M.O., Zhukova, L.V., Stankevych, S.V., Zayarna, O.Yu., Lukhanin, I.V., Oleynikov, Ye.S., Batova, O.M., Goryainova, V.V., Poedinceva, A.A. (2019). Dependence of species composition and development of root rots pathogens of spring barley on abiotic factors in the Eastern Forest–Steppe of Ukraine. *Ukrainian Journal of Ecology, 9*(2), 179–188.
Vasilyev, V.P. (1993). Dovidnik po zahistu polovih kultur. Kyiv, Urozhaj, 447 (in Ukrainian).
Zhukova, L.V., Stankevych, S.V., Turenko, V.P., Bezpal'ko, V.V., Zabrodina, I.V., Bondarenko, S.V., Poedinceva, A.A., Golovan, L.V., Klymenko, I.V., Melenti, V.O. (2019). Root rots of spring barley, their harmfulness and the basic effective protection measures. Ukrainian Journal of Ecology, 9(2), 232–238.

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