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The level of intensity of soft winter wheat varieties infection by *Fusarium* link pathogens and their identification on grain

Abstract. In modern conditions, an important task of agricultural production is to increase the yield and improve the quality of agricultural products. A reliable and environmentally beneficial factor for a sustainable increase in yield and improvement of grain quality is the creation of new varieties with group resistance to diseases and a high level of adaptability. The effectiveness of breeding for immunity directly depends on the diversity of donor resistance genes, and the search for new sources of resistance has been and remains a topical issue. The purpose of the study was to establish the level of infection of grain of soft winter wheat varieties with pathogens of Fusarium head blight and their identification. Winter wheat varieties from different breeding institutions of Ukraine were used in the research: V.M. Remeslo Myronivka Institute of Wheat of NAAS (MIW), Breeding and Genetic Institute – National Centre for Seed Breeding and Variety Research of NAAS (SGI-NCNS), V.Ya. Yuriev Plant Production Institute of NAAS (PPI), Institute of Plant Physiology and Genetics of NASU (IPPG), Institute of Plant Protection of NAAS (IPP), Institute of Irrigated Agriculture of NAAS (IA), National Research Centre "Institute of Agriculture" of NAAS (NRC IA). Phytopathological analysis was used to determine the species composition of the *Fusarium* Link pathogen, and the proportion of species was determined by the ratio of infected wheat grain samples to their total number. A higher (15-18%) level of intensity of Fusarium blight infection was observed in the varieties Doskonala, Turunchuk, Ovidii, Vodohrai,

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and Myroliubyva. Winter wheat grain in the years of research was colonised by such types of *Fusarium* head blight as: F. *sporotrichiella*, F. *monilifopme*, F. *graminearum*, F. *culmorum*, F. *avenaceum*, F. *gibbosum* F. *sambucinum* and F. *oxysporium*. F. *monilifopme* and F. *oxysporium* species dominated the situation, with their prevalence on wheat grain being 16.2 and 1.7%, respectively. Winter wheat varieties with the lowest (1.2–4.5%) damage by pathogens of the genus *Fusarium* are recommended for use in wheat breeding for immunity. The use of a stable starting material in practical breeding will help contain the increase in infection of pathogens without the use of chemical protective equipment

Keywords: *Triticum aestivum* L., source material, seed infection, *Fusarium* head blight, fungi of the genus Fusarium, species composition, dominant species

INTRODUCTION

Wheat is grown in more than 80 countries around the world and is the main food product in 43 of them (Bakumenko *et al*., 2019). It is one of the most productive and valuable food crops, (Shpaar *et al*., 2012; Leonov *et al*., 2016) are convinced that in the future the importance of wheat will constantly grow and this particular crop will become the most important on the globe. Pathogenic microorganisms accompany soft winter wheat from the moment of sowing to harvesting and storage. Even minimal damage to its diseases leads to large overall crop losses (Kirichenko, 2016). Diseases significantly reduce the yield and quality indicators of grown products. Losses of the gross grain harvest annually amount to about 25-30 % (Savary *et al*., 2019). As evidenced by M. Kayim *et al* (2022) "almost 22% of wheat crop losses were caused by diseases. These percentages will increase over time due to mutations and diversity of virulent strains." Success in addressing these issues mainly depends on the effectiveness of genetic improvement of wheat varieties (Mukha & Murashko, 2019). Selection of soft winter wheat has reached a level where its potential yield is largely related to the stability of the varieties grown. Selection for wheat resistance against phytopathogens allows reducing their harmful effect. Creating and growing disease-resistant varieties allows protecting the crop, preserving the environment, and saving money, so one of the most effective measures is to use resistant varieties (Deutsch *et al*., 2018).

The effectiveness of immunity breeding depends on the availability of a well-studied source material and a scientifically based approach to its use. The main components of the methodology for creating such material are regular monitoring of the pathogenic complex, morphophysiological properties of plants and populations of particularly dangerous pathogens, objectivity in assessing the immunological properties of varieties, establishing relationships in the plant-host-pathogen system, identifying and selecting highly effective sources and donors adapted to zonal conditions (Bushulian, 2018). In Ukraine, work on the creation of raw materials for wheat breeding with group resistance against different species of powdery mildew, rust, septoria, *Fusarium* blight, stinking smut, and cercosporella leaf spot is successfully conducted at the Institute of Plant Protection of NAAS, V.M. Remeslo Myronivka Institute of Wheat (MIW) and Breeding and Genetic Institute – National Centre for Seed Breeding and Variety Research of NAAS (SGI-NCNS) *etc.* (Kovalyshina *et al*., 2018).

Grain crops can be affected by more than 300-350 species of various organisms. These are insects, fungi, bacteria, viruses, nematodes, rodents, weeds, etc. But the main threat to crop loss, especially in the initial stages of development, in the autumn-winter period is represented by pathogens of fungal infections, among which one of the leading places is occupied by micromycetes of the genus *Fusarium* (Ryabovol *et al*., 2019). The widespread distribution of *Fusarium* fungi, their variability, and indisputable evidence of the danger posed to human and animal health by mycotoxins, generate the interest of the scientific community (Ostrovsky *et al*., 2017; Janik *et al*., 2020). Plant damage involves a complex of fungi of this genus, which differ in biology and adaptation to the conditions of the biocenosis in different areas of grain cultivation (Nazarenko & Lykholat, 2018; Birr *et al*., 2020). They cause damage at all stages of organogenesis of winter wheat plants, reduce the energy of germination and field germination of seeds, and worsen the baking properties of flour. The danger of *Fusarium* blight infection lies not only in a decrease in the grain yield, but also in contamination of grain with *fusarium* toxins, which leads to a weakening of plants during their further development, it can only be detected by mycological analysis (Topi *et al*., 2020).

The purpose of the study was to determine the level of infection of grain of soft winter wheat varieties with pathogens of *Fusarium* head blight and identify them. According to Mostoviak *et al*., (2020) questions of morphology, biology, biochemistry, physiology, and genetics of fungi of the genus *Fusarium,* and the search for ways to limit their number in the agrobiocoenoses of field crops and reduce the number today is of considerable interest to both Ukrainian and foreign researchers. A number of studies have been devoted to the issues of wheat resistance to *Fusarium* head blight depending on the sensitivity of the variety and meteorological factors, grain quality, and mycotoxin contamination. Góral *et al*. (2018); Zhu *et al*. (2019); Birr *et al*. (2020); Martínez *et al*. Karelov *et al*. (2021) recommend the use of a polymerase chain reaction test (PCR test) for more accurate quantitative and qualitative genus and species-specific identification of *Fusarium* on durum wheat. Bahadur (2022) found that new populations of *Fusarium* will continue to appear due to microevolution and the invention of exotic pathogens. The researcher recommends the use of resistant varieties and biological control agents for disease control (*Trichoderma* spp. and *Psedomonas* spp.). D. Naguib (2018) investigated the effect of treatment of wheat grains with defensin (low-molecular-weight positively charged proteins with a high cysteine content) on the resistance of cultivated plants against *fusarium* wilt as one of the methods of biological protection of crops. It was found that priming improves the antioxidant system of plants, initiates the regulation of protective signalling molecules, such as jasmonic and abscisic acids, which, in turn, activate the expression of several protective genes for a number of diseases, including *Fusarium* blight. Another biosecurity method is proposed by L. Shcherbakova *et al.* (2018), who found that the extract purified from the mycelium of the strain *Fusarium sambucinum* controlling tomato wilt can protect wheat from *Fusarium* blight and common root rot.

Scientists are very interested in identifying and studying *Fusarium* blight pathogens in other field crops. In particular, research by B. Kalman *et al.* (2020) conducted in north-eastern Israel for the first time identified and characterised species of *Fusarium* spp., pathogens of basal rot of onions: *F. proliferatum*, *F. oxysporum* F. sp. *cepae* and two species that are less well known as pathogens of this disease, *F. Acutatum* and *F. anthophilium*. The research was a necessary step towards identifying the mycoflora of diseased onion plants and developing a preventive programme that would reduce the harm from the disease. Due to insufficient information on the molecular epidemiology of *Fusarium* wilt of the important yams root crop in China (*Dioscorea polystachya* Thunb.) a number of studies by a group of Chinese researchers F. Dongzhen *et al.* (2020) were aimed at identifying species and strains of fungi of the genus *Fusarium* and establishing links between pathogen strains and populations. The attention of researchers to the important scientific problem of *Fusarium* head blight infection and the search for ways to protect determines the relevance of the conducted research, which consisted in studying *Fusarium* blight on an artificial infectious background and identifying sources of resistance among winter wheat varieties.

MATERIALS AND METHODS

The research was conducted during 2021-2022 at the winter wheat breeding laboratory of the V.M. Remeslo Myronivka Institute of Wheat of NAAS of Ukraine (Tsentralne village, Obukhiv district, Kyiv oblast) in the northern part of the Right-Bank Forest-Steppe. The object of research was grain of soft winter wheat varieties grown in the field on an artificial infectious background of *Fusarium* head blight harvest 2021-2022 from different breeding institutions of Ukraine: V.M. Remeslo Myronivka Institute of Wheat of NAAS (MIW), Breeding and Genetic Institute – National Centre for Seed Breeding and Variety Research of NAAS (SGI-NCNS), V.Ya. Yuriev Plant Production Institute of NAAS (PPI), Institute of Plant Physiology and Genetics of NASU (IPPG), Institute of Plant Protection of NAAS (IPP), Institute of Irrigated Agriculture of NAAS (IA), National Research Centre "Institute of Agriculture" of NAAS (NRC IA). Distribution of grain *Fusarium* blight pathogens and species composition of fungi of the genus *Fusarium* Link was studied on 23 varieties of winter wheat from different breeding centres of Ukraine (Doskonala, Pryvablyva, Stolychna, Fermerka, Mriya, Poverna (PPI), Turunchuk, Zvytiaha, Kosovytsia, Viktoria, Bezmezhna (SGI-NCNS), Vodohrai, Myroliubyva, Polisianka (NRC IA), Voloshkova (MIW, IPPG), Chornyava, Tsyhanka (IPPG), Blaho, Ovidii (IA)), and sources of stability – Myronivska early ripening/CATALON, MV 20-88/Smuhlianka, BILINMEVEN 49/Natalka, Donskoy prostor/Slavna, (Mikon/ALMA)/Legenda Myronivska (MIW).

To identify species of *Fusarium* Link in laboratory conditions, phytopathological analysis of grain of soft winter wheat varieties was carried out in accordance with the methods of conducting phytopathological studies and the methodology for assessing the resistance of wheat varieties against pests and pathogens (Volkodav *et al.*; 2001; Tribel *et al.*, 2010; Methods..., 2016). Seeds (100 pcs.) each of the 23 studied varieties of winter wheat was disinfected for 5 minutes in a 0.5% solution of $KMnO4$, then it was washed with sterile water and dried between sheets of filter paper, flamed in the flame of an alcohol lamp and laid out in 10 pieces on a sterile nutrient medium (potato-glucose agar (PGA) with the addition of an antibiotic of antibacterial action – streptomycin sulphate). Cups of grain were incubated in a thermostat at 25°C for five days. After this period, each micromycete isolated from the seed to the surface of the nutrient medium was transplanted into a separate tube with PGA for further identification of the pathogen type.

To determine the species composition of fungal pathogens (seed infection) on the grain of the 2021-2022 harvest, phytopathological analysis of grain samples was carried out in the laboratory conditions of the institute. Isolates were examined at Day 5-7, recording the presence or absence of microconidia. The final identification of pathogens was carried out by microscopic examination, considering morphological features, the presence or absence of chlamydospores of the pathogen (Volkodav *et al.*, 2001; Tribel *et al.*, 2010; Methods..., 2016). The species name of the fungi was determined according to Bilai *et al.* (1988). The frequency of the species was determined by the ratio of grain samples where it was found to the total number of samples studied and expressed as a percentage.

RESULTS AND DISCUSSION

The average air temperature in the period August 2021 – July 2022 was 9.3°C, which is 0.4°C more than the long-term average (Table 1). In August and November 2021, the average monthly air temperatures exceeded the long-term average by 0.1 and 2.4°C, respectively, and in September and October they were lower by 1.7 and 1.1°C. In the spring-summer growing season of wheat, the average monthly temperatures were 0.1-1.5°C lower than long-term ones, only in June they were 1.4°C higher.

Table 1. Meteorological conditions during the years of research, Myronivka

Year	Month	Air temperature, °C			Amount of precipitation, mm			
		actual	multi-year	±*	actual	multi-year	±*	%*
2021	August	20.5	20.4	0.1	109	55	54	198
	September	13.2	14.9	-1.7	27	58	-31	46
	October	7.6	8.7	-1.1	26	43	-17	60
	November	4.8	2.4	2.4	41	40	1	101
	December	-1.1	-1.8	0.7	94	42	52	223
2022	January	-1.2	-3.7	2.5	33	39	-6	86
	February	1.7	-2.5	4.2	10	33	-23	32
	March	2.3	2.4	-0.1	13	39	-26	32
	April	8.3	9.8	-1.5	143	41	102	349
	May	14.7	15.7	-1.0	42	61	-19	70
	June	20.7	19.3	1.4	58	87	-30	66
	July	20.4	21.1	-0.7	68	75	-7	91
Per year		9.3	8.9	0.4	663	615	48	108

Source: observation logs of the Myronivka meteorological station
Note: * ± – difference to multi-year; % – percentage to multi-year

From August 2021 to July 2022, 663 mm of precipitation fell (108% of the long-term average). Precipitation in August (109 mm, 198% of the long-term amount) contributed to the production of uniform wheat shoots. In the spring-summer growing season of winter wheat, a sufficient amount of moisture was observed, although the amount of precipitation was 7-30 mm lower than the long-term one, only in April 349% of the average long-term amount fell. The duration of the period from germination to the end of vegetation in 2021 was at the level of long-term (59 days), the dormant period was shorter by 8 days. The level of hydrothermal coefficient (HTC) and its dynamics in the spring-summer growing season are shown in Figure 1. According to the indicator of water supply, the reporting year refers to a year with a weak drought (HTC=0.9). In the spring-summer growing season of winter wheat, insufficient moisture was observed (HTC was 0.8). The average duration of winter wheat development periods and the distribution of precipitation depending on these periods are shown in Table 2.

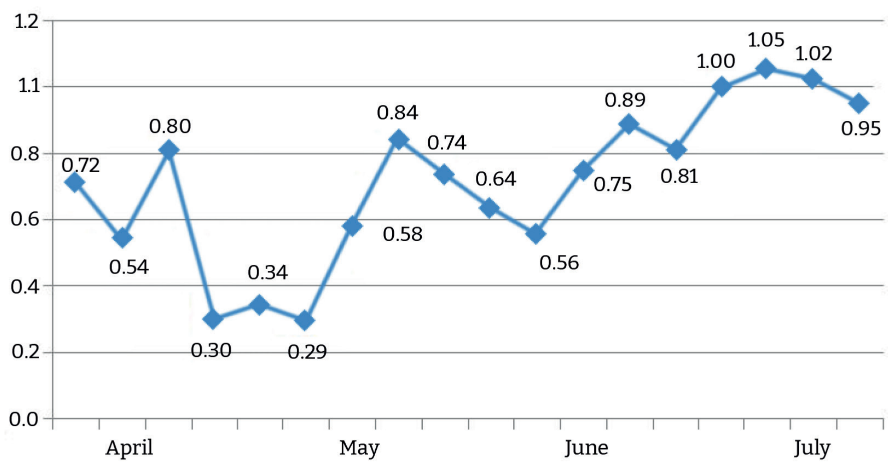

Figure 1. Dynamics of the hydrothermal coefficient in the spring-summer vegetation period of winter wheat, 2022

Table 2. Hydrothermal regime of winter wheat development by period (2020-2021)

Year termination of vegetation	Periods of winter wheat development							Amount		Number of days from sowing to	
	beginning of the dormant period – restoration of vegetation	restoration of vegetation – stem elongation	stem elongation – earing	earing – milk ripeness	milk ripeness – waxy ripeness	waxy ripeness – threshing			waxy ripeness	threshing	
Precipitation, mm											
2021/22	53.2	161.7	148.5	36.3	3.0	55.1	67.4	525.2		–	–
multi-year	124.4	245.8	60.6	62.4	77.1	32.5	73.2	675.9		–	–
Sum of active temperatures of 5 °C and more											
2021/22	346.3	64.3	511.4	206.8	361.2	286.2	503.8	2,280.0		–	–
multi-year	479.1	77.2	298.1	399.8	484.3	312.5	342.9	2,359.9		–	–
Average daily air temperature, °C											
2021/22	6.6	-0.01	9.9	14.8	20.1	20.4	20.2	–		–	–
multi-year	8.9	-1.9	9.1	15.4	19.3	21.0	20.9	–		–	–
Duration of individual periods, days											
2021/22	58	118	54	14	18	15	24	–		276	301
multi-year	59	126	37	27	25	15	17	–		290	307

Source: observation logs of the Myronivka meteorological station

As a result of the conducted studies, it was found that the average intensity of winter wheat *Fusarium* blight infection was 9.3% (Table 3). This indicator in the studied varieties differed significantly, and according to the level of damage intensity, all the studied varieties can be divided into several groups. Lowest percentage of damage (1.20-4.5 %) was noted in the varieties Bezmezhna (SGI-NCNS), Poverna (PPI), Polisianka (NRC-IA), the second group included varieties – Zvytiaha, Kosovytsia (SGI-NCNS), Pryvablyva, Stolychna (PPI), Tsyhanka (IPPG), Voloshkova (MIP, IPPG) (8.1-11.5%), the third – Chorniava (IPPG), Mriya (PPI), Viktoria (SGI-NCNS), Blaho (IA), Fermerka (PPI) (5.1-7.5%).

According to the resistance to this pathogen on an artificial infectious background in the field, MIW identified in previous years (2016-2020): ((MV – 20-88/Smuglyanka), BILINMEVEN-49/Natalka, Donskoy prostor/Slavna, Mikon/ALMA)/Legenda Myronivska, Myronivska early-maturing/Catalon), they are involved in direct and reverse crosses as parent forms when creating new hybrid combinations for resistance against *Fusarium graminearum*. The highest intensity of damage was observed in wheat varieties Natula (POL), Doskonala (PPI), Turunchuk, Ovidii (IA), Vodohrai, Myroliubyva (NRC IA) (15.1-25.1 %).

Table 3. Characteristics of the best varieties of soft winter wheat in terms of resistance against pathogen *Fusarium graminearum*, (average for 2021-2022)

Variety, breeding line	Country of origin	Intensity of damage, %	Intensity of damage, %± to the vulnerable variety
Natula (vulnerable variety)	POL	25.1	–
Doskonala	PPI	15.2	+9.9
Turunchuk	SGI-NCNS	16.3	+8.8
Ovidii	IA	15.5	+9.3
Vodohrai	NRC IA	15.1	+10.0
Myroliubyva	NRC IA	15.3	+9.8
Zvytiaha	SGI-NCNS	10.2	+14.9
Kosovytsia	SGI-NCNS	11.5	+13.6
Pryvablyva	PPI	8.1	+17.0
Tsyhanka	IPPG	6.6	+18.5

Table 3, Continued

Variety, breeding line	Country of origin	Intensity of damage, %	Intensity of damage, %± to the vulnerable variety
Voloshkova	MIW, IPPG	9.1	+16.0
Stolychna	PPI	8.3	+16.8
Chorniava	IPPG	7.5	+17.6
Mriya	PPI	5.2	+19.9
Viktoria	SGI-NCNS	6.4	+18.7
Blaho	IA	5.1	+20.0
Fermerka	PPI	5.3	+19.8
Bezmezhna	SGI-NCNS	4.5	+20.6
Poverna	PPI	3.3	+21.8
Polisianka	NRC IA	3.1	+22.0
Myronivska early ripening/CATALON	MIW	1.2	+23.9
MV 20-88/Smuhlianka	MIW	1.2	+23.9
BILINMEVEN49/Natalka	MIW	1.3	+23.8
Donskoy prostor/Slavna	MIW	1.3	+23.8
(Mikon / ALMA)/Legenda Myr	MIW	1.2	+23.9

Source: field journals of phenological observations of the winter wheat breeding laboratory of the V.M. Remeslo Myronivka Institute of Wheat of NAAS for 2021-2022

The species composition of fungi of the genus *Fusarium* Link on soft winter wheat grain is established (Fig. 2), which included the presence of eight species, the predominant of which were three: *sporotrichiella* (14.4%), *oxysporium* (11.3%) *culmorum* (8.1%).

The pathogen *F. sporotrichiella* was detected on the grains of 16 varieties of winter wheat, and the highest damage was observed in varieties Turunchuk, Pryvablyva, Voloshkova, and Blaho (36.1-46.9%). *F. oxysporium* affected only 11 varieties, the most vulnerable – the Doskonala variety (50%). The third most common type of *Fusarium* infection was *F. culmorum* with a damage rate of 8.1%, in other species, the proportion of the intensity of wheat grain damage was noted in the range from 2.2 to 6.5% (Fig. 2).

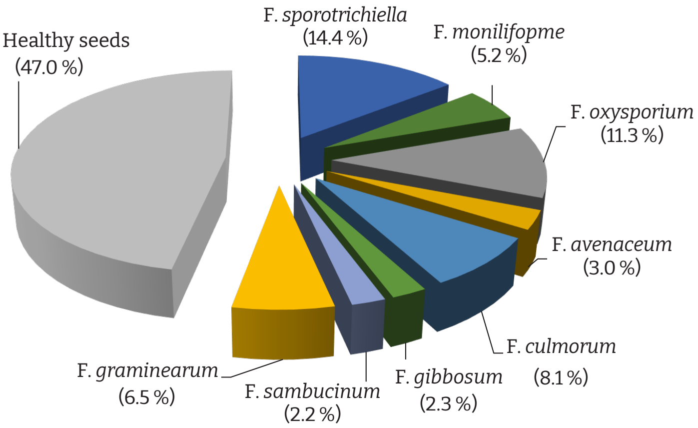

Figure 2. Species composition of fungi of the genus *Fusarium* Link on soft winter wheat grain (MIW, average for 2021–2022)

High resistance against the causative agent of *Fusarium* blight was observed in sources (lines) created in MIW – Myronivska early-maturing/CATALON, MV 20-88/Smuglyanka, BILINMEVEN49/Natalka, Donskoy prostor/Slavna and (Mikon/ALMA)/Legenda Myronivska, the percentage of healthy grains reached 76.6%. The average level of damage intensity was identified as wheat varieties Kosovytsia, Stolychna, Mriya, and Bezmezhna, the percentage of healthy grains was within 55.5-65.6% (Table 4).

Table 4. Species composition of *Fusarium* blight infection on winter wheat grain, average for 2021-2022

Variety, breeding line	Proportion of fungi of the genus *Fusarium* on grain, %								
	F. sporotrichiella	***F. monilifopme***	***F. oxysporium***	***F. avenaceum***	***F. culmorum***	***F. gibbosum***	***F. sambucinum***	***F. graminearum***	**Healthy grains, %**
Natula (vulnerable variety)	18.0	–	25.1	–	25.0	–	–	10.2	21.7
Doskonala	10.1	14.9	50.1	–	–	–	–	9.1	15.8
Turunchuk	39.9	–	30.1	–	–	10.3	–	–	19.7
Kniahynia Olha	25.2	4.8	25.0	–	25.1	–	–	–	19.9
Vodohrai	–	–	29.3	–	22.3	–	15.4	–	33.0
Myroliubyva	18.5	20.5	–	10.2	10.8	5.1	–	–	34.9
Zvytiaha	12.1	9.9	–	–	15.9	–	–	10.1	52.0
Kosovytsia	–	8.5	–	–	8.1	3.9	6.1	7.8	65.6
Pryvablyva	38.1	–	6.9	–	10.1	10.3	–	–	34.6
Tsyhanka	17.2	–	36.1	17.5	–	–	–	–	29.2
Voloshkova	46.9	–	–	–	18.1	–	–	–	35.0
Stolychna	12.2	6.3	11.1	–	14.9	–	–	–	55.5
Chorniava	24.5	–	25.5	–	–	–	–	5.5	44.5
Mriya	18.2	12.1	–	10.2	–	–	–	–	59.5
Viktoria	–	–	10.4	5.6	–	15.0	–	22.3	46.7
Blaho	36.1	10.2	–	–	14.1	–	2.7	–	36.9
Fermerka	–	–	–	–	–	–	8.5	40.3	51.2
Bezmezhna	–	10.3	–	–	25.1	–	–	–	64.6
Poverna	32.1	–	15.5	–	–	8.3	–	–	44.1
Polisianka	–	15.1	–	14.5	–	–	–	20.3	50.1
Myronivska early ripening/CATALON	–	5.1	9.8	4.2	5.1	–	–	10.1	65.7
MV 20-88/Smuhlianka	9.8	8.5	–	–	–	–	10.1		71.6
BILINMEVEN49/Natalka	3.5		2.4	–	–	–	8.2	9.3	76.6
Donskoy prostor/Slavna	–	5.6		6.7		3.5		8.9	75.3
(Mikon / ALMA)/Legenda Myr	–	–	6.4	–	9.6	–	2.9	10.8	70.3
Isolation frequency, %	14.4	5.2	11.3	3.0	8.1	2.3	2.2	6.5	–

Source: field journals of phenological observations of the winter wheat breeding laboratory of the V.M. Remeslo Myronivka Institute of Wheat of NAAS for 2021-2022

Compared to the variety Natula (25.1%) susceptible to *Fusarium* infection, the proportion of healthy grains was low in the varieties Doskonala (15.8%), Turunchuk (19.7%), Ovidii (19.9%), and Tsyganka (29.3%), indicating a high level of *Fusarium* infection.

Climate changes caused by global warming lead to sharp changes in air temperature both in winter and summer, which cause long periods of drought in summer and sudden frosts during the spring growing season of field crops. Miedaner & Juroszek (2021), Juroszek & Tiedemann (2013) point out that global climate change threatens wheat productivity in the context of the significant impact of air temperature and humidity on the development of pathogens. These weather changes negatively affect not only cultivated plants, but also the development of pathogens (Jarroudi *et al*, 2017; Jarroudi *et al.*, 2018). Scope of variation in the intensity of damage to varieties by *Fusarium* pathogens can be determined not only by the characteristics of genotypes, but also by such non-random factors as the influence of environmental conditions. Meteorological conditions during the years of research were not very favourable for the development of the pathogen *Fusarium graminearum* Schwabe, the average intensity of winter wheat *Fusarium* infection was 9.3 %.

F. Doohan research *et al.* (2003) proved that the establishment of the species composition and the ratio of species is significantly influenced by weather conditions, in particular, the humidification regime. The main role here is played not by all precipitation during the season, but only by those that fell during the flowering period – grain maturation, they determine the level of development and spread of the disease. These findings are consistent with the results of studies conducted in the context of the regime of moisture supply during the flowering period – grain maturation on the species composition of fungi of the genus *Fusarium* Link. During the years of research, the amount of precipitation during the flowering and ripening period of winter wheat grain was significantly lower than the long-term indicator.

N. Carlo *et al.* (2021) argue that in the field it is not always possible to create a levelled artificial infectious background due to the influence of environmental conditions, as a result – a decrease in the intensity of the manifestation of the disease, and the resulting intensity of the damage may not correspond to the actual assessment of the stability of an individual sample. The conducted studies indicate that the intensity of damage to soft winter wheat plants by the *Fusarium* pathogen was determined within 1-35%, the average development of the disease was 15.8%. Hybridisation can significantly increase the availability of genotypic diversity in terms of resistance. M. Figueroa *et al.* (2018) consider it appropriate to create an artificial background of pathogens in the field and laboratory to differentiate the initial breeding material by the corresponding trait under controlled conditions. This, in turn, would contribute to the selection of stable forms, adjust the further areas of breeding work, and accelerate the creation of stable source material.

21 species of fungi of the genus *Fusarium* are described in the scientific literature, which are most often present in the pathogenic complex of Ukraine. According to S. Choni (2014), depending on weather conditions, grain crops are affected by 5-10 species, the most common and most dangerous among which are F.*graminearym* and F.*culmorum*. Frequency of isolation of pathogens typical of Ukrainian conditions, such as *F. graminearum* and *F. sulmorum*, gradually decreases, and other types of pathogens that can develop in dry weather conditions begin to dominate. The danger of these pathogens lies in the fact that it is quite difficult to visualise them at the stage of grain development in the conditions of each specific experiment, which is confirmed by the research of Mykhailska *et al.* (2019). Two types of fungus dominated the experiment, the first of which was *F. sporotrichiella* , the frequency of its dominance was in the range from 3.5 to 39.9 %, and the second-found species – *F. oxysporium* – the dominance of which was from 2.4 to 50.1 %. In addition to the immediate threat to seed material and its quality, pathogens *F. sporotrichiella*, which predominate in the pathogenic complex, produce trichothecin mycotoxins. These substances can cause acute poisoning in humans and animals, in addition, studies note that in laboratory conditions, strains of *F. sporotrichiella* at a temperature of +26-28°C is able to synthesise and accumulate mycotoxins three times faster (Awuchi *et al.*, 2021). One of the most effective ways to prevent the spread of *Fusarium* head blight disease is to create and introduce wheat varieties resistant to *Fusarium* blight and proper agricultural techniques of crops into production.

CONCLUSIONS

Fusarium head blight is one of the most common and harmful diseases among winter wheat diseases, which is one of the leading diseases of winter wheat in terms of its prevalence and significance. At the same time, the climatic changes towards aridity that were observed on the territory of Ukraine in recent years do not contribute to the loss of a significant part of the crop from *Fusarium* blight, since only in wet and warm weather during the flowering period of winter wheat *Fusarium* wilt can develop so much that quantitative losses will be very significant. However, the result of the vital activity of *Fusarium* fungi is a whole set of mycotoxins that can significantly degrade the quality of grain, so one of the most effective ways to prevent the spread of *Fusarium* blight without the use of chemical means of protection is to use a stable starting material when creating new varieties.

The smallest damage (1.2-4.5%) by the *Fusarium* blight was characterised by winter wheat varieties Bezmezhna, Poverna, Polisianka and sources of resistance (lines) – Myronivska early-maturing/CATALON, MV 20-88/Smuglianka, BILINMEVEN 49/Natalka, Donskoy prostor/Slavna and (Mikon/ALMA)/Legenda Myronivska (1.2-4.5%), which are recommended for use in breeding for immunity. The highest isolation frequency was characterised by the type *F. sporotrichiella* (14.4%), second place – *F. oxysporium* (11.3%), third – *F. culmorum* (8.1%), and F. *graminearum* (6.5%) shared fourth place with *F. monilifopme* (5.2%). Partially observed species *F. sambucinum* (2.2%), *F. avenaceum* (3.0%), and F. *gibbosum* (2,3%).

Study of the prevalence and presence of the species composition of fungi of the genus *Fusarium* allows screening of wheat varieties and detection of samples less infected with *fusarium* infection. This is important for breeding programmes when choosing optimal wheat varieties for resistance against *Fusarium* blight pathogens.

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Рівень інтенсивності ураження сортів пшениці м'якої озимої збудниками *Fusarium* link та їх ідентифікація на зерні

Анотація. В умовах сьогодення важливим завданням аграрного виробництва є підвищення рівня врожайності та покращення якості продукції сільськогосподарських культур. Надійним та екологічно вигідним фактором стійкого збільшення врожайності та поліпшення якості зерна є створення нових сортів з груповою стійкістю проти хвороб та високим рівнем адаптивності. Ефективність селекції на імунітет прямо залежить від різноманіття складу генів стійкості донорів, топу пошук нових джерел стійкості було і залишається актуальним питання. Мета досліджень полягала у встановленні рівня інфікованості зерна сортів пшениці м'якої озимої збудниками фузаріозу колоса та їх ідентифікації. В дослідженнях використовували сорти пшениці озимої різних селекційних установ України: Миронівського інституту пшениці імені В. М. Ремесла НААН (МІП), Селекційно-генетичного інституту – Національного центру насіннєзнавства та сортовивчення НААН (СГІ-НЦНС), Інституту рослинництва ім. В. Я. Юр'єва НААН (ІР), Інституту фізіології рослин і генетики НАНУ (ІФРГ), Інституту захисту рослин НААН (ІЗР), Інституту зрошуваного землеробства НААН (ІЗЗ), Національного наукового центру «Інститут землеробства» НААН (ННЦ ІЗ). Для визначення видового складу збудника *Fusarium* Link використовували фітопатологічний аналіз, частку видів – співвідношенням інфікованих зразків зерна пшениці до їх загальної кількості. Вищий (15-18 %) рівень інтенсивності ураження фузаріозною інфекцією спостерігали у сортів Досконала, Турунчук, Овідій, Водограй, Миролюбива. Зерно пшениці озимої у роки досліджень колонізувалось такими видами фузаріозу як: F. *sporotrichiella*, F. *monilifopme*, F. *graminearum*, F. *culmorum*, F. *avenaceum*, F. *gibbosum* F. *sambucinum* та F. *oxysporium*. Домінуючу ситуацію займали види F. monilifopme та F. oxysporium, їх пошириність на зерні пшениці становила 16,2 та 1,7 % відповідно. Виокремлені сорти пшениці озимої з найменшим (1,2-4,5 %) ураженням збудниками роду *Fusarium* рекомендовано для використання в селекції пшениці на імунітет. Використання в практичній селекції стійкого вихідного матеріалу дозволить утримувати наростання інфекції збудників хвороб без застосування хімічних засобів захисту

Ключові слова: *Triticum aestivum* L., вихідний матеріал, насіннєва інфекція, фузаріоз, гриби роду *Fusarium*, видовий склад, домінуючі види