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Original article

Phytosanitary Status of Wheat Crops in Northeastern Bulgaria

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Abstract

In the present work, the results of a survey of wheat crops in the area of the IASS "Obraztsov chiflik" – Ruse are presented. The study was carried out during the period 2018-2021, at the experimental field of the institute, according to accepted methods for weed infestation, species composition of the entomofauna and economically important wheat diseases.

The aim of the study is to determine the species composition of weeds, diseases and insect pest in wheat crops under the relevant agro-climatic conditions.

Weed species composition differed by year, with a total of 15 weed species from 10 families recorded. *Veronica agrestis* L., *Lamium purpureum* L., *Anthemis arvensis* L., *Convolvulus arvensis* L. and *Cirsium arvense* L. are ubiquitous in surveyed crop.

Insects belonging to the orders Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Neuroptera and Orthoptera were identified. The proportion of the orders to which the species belonged in the three years of the study differed in culture. The total number of insects detected during the three years of the test varied on average (CV=15.63%) – 373 pcs. in 2019, 280 pcs. in 2020 and 372 pcs. in 2021.

During the period, 3 fungal pathogens of the genera *Puccinia, Erysiphe* and *Septoria* were identified. The development of *Puccinia* and *Erysiphe* pathogens during the study period was within acceptable limits according to the SEV scale (from 10% to 25%). Massive development of the pathogen *Septoria sp*. was observed, with the affected plant area reaching up to 65%, according to the SEV scale.

Keywords: Wheat, Phytosanitary Monitoring, Weeds, Diseases, Pests.

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INTRODUCTION

Wheat is a major cereal crop that has been the subject of much research (Dochev et al, 2019). In recent years, the areas sown with wheat have been significant and have remained stable over the years, especially in North-Eastern Bulgaria. The main problem with cereal crops is phytosanitary status - weeds, pests and diseases. Its constant relevance is supported by the great dynamics of species and communities in crops. Dynamic changes are associated with the significant variability of weather conditions, with changes in crop cultivation technologies and with changes in the economic conditions of grain production. Overgrowing with weeds, the development of diseases and pests in the areas sown with wheat are some of the main unfavorable factors that limit the yield and its quality. In individual years, losses vary from 10 to 85% (Niekerk et al., 2013; Stoyanova et al., 2017).

The pests of cereal crops can cause annual damage of 13.8% of production, against 11.6% damage caused by pathogens and 9.5% by weeds (Talmaciu et al., 2016). Weed mapping plays an important role and has become extremely important in recent decades, due to the dynamically developing compensation processes, especially clearly expressed in cereal crops (Mitkov et al., 2009; Atanasova et al., 2010).

The aim of good plant protection practice is to control emerging and widespread weeds with the most suitable herbicides applied in time. If the recommendations for proper tillage of the soil, the time of sowing and sowing norms, balanced mineral fertilization are followed, conditions are created for well-arranged and competitive crops with regard to weeds. Before treating the wheat crops, it is necessary to walk around the areas, assess the degree of weeding and the species composition, the phenophases of the crop and the weeds and, if necessary, proceed to spray, selecting the most suitable herbicides, the exact dose and their time of application (Tityanova et al., 2007; Delibaltova et al., 2009; Tonev, 2012). Wheat is also attacked by various pests (Özgökçe et al., 2022). Under favorable climatic conditions, they can multiply significantly and cause significant damage to the plants and reduce the yield and quality of the produce. The pests with sucking-type mouth apparatus inject toxins during feeding, transmitting viral diseases to plants (Maneva & Lecheva, 2012). A number of soil-inhabitation pathogens of the genus *Fusarium*, *Drechslera*, *Rhizoctonia*, etc. are among the causes of the diseases of greatest economic importance for Bulgaria. (Strausbaugh et al., 2005; Yanashkov & Valchev, 2016; Yanashkov et al., 2017). No complex monitoring studies have been conducted in the area of the Danube Plain regarding the phytosanitary status of wheat.

The aim of the study is to determine the species composition of weeds, diseases and pests in wheat crop under the relevant agro-climatic conditions.

MATERIAL and METHODS

During the period 2018-2021, in the experimental field of the Institute of Agriculture and Seed Science "Obratzov chiflik" - Ruse, Bulgaria, monitoring was carried out in wheat crops of the "Venka 1" variety, to establish the species composition of weeds, pests and diseases.

Wheat was sown in the optimal period for the region, which is determined based on its agro-meteorological requirements, climatic conditions and the predecessor after which it is sown. The parcel located for this purpose is on the territory of the Institute, on a highly leached chernozem soil type and is characterized by a poor humus content of 1.75%, poorly stocked with mineral N (19.75 mg/1000 g of soil) and mobile P_2O_5 (5.31 mg/100 g soil) and well stocked with K_2O (22.75 mg/100 g soil) in the layer 0 - 40 cm. The soil reaction is moderately acidic (pH in KCL – 5.0%). The mechanical composition of the soil is heavy sandy-clay (Nenova et al., 2011).

Weeds were counted according to the diagonal method, on an area of 1ha, according to the adopted uniform methodology for reporting and mapping the weeds in agricultural areas (Dimitrova et al., 2004) and determined according to Delipavlov et al (2011), with all species occurring in the areas recorded. The weed reporting was carried out by the quantitative-weight method (pcs/m^2; g/m^2) in the tillering and at the beginning of the heading stages of wheat. To determine the weediness of the crops, a sampling plot with an area of 0.25 m^2 was used, which was placed in several places along the diagonals of the surveyed field. In each sampling plot, the stems of the cultivated plant were counted and all weed plants, regardless of their stage of development, were counted too. Weeds are sorted by species, counted and, after reaching an air-dry condition, weighed, thereby establishing not only the number of weeds relative to the number of cultivated plants but also their above-ground mass per unit area.

To establish the species composition of the wheat entomofauna, the classical method of cutting with a standard sweeping net (quantitative and qualitative method) was used. The species composition and quantity of the entomofauna was recorded in samples of 25 slopes = 5m^2. The samples were taken in two replications, once a week in clear and calm weather. The species classification was made according to Boychev (1979), according to which: dominant species have more than 15% participation, subdominant species - from 5 to 15%, and secondary species - from 1 to 5%. The monitoring was carried out from the beginning of April until the harvesting of the crop.

For the study of wheat diseases, records were made in the period from the beginning of April until harvesting. Through phytopathological observations, the degree of attack and development of the economically important diseases in wheat, including pathogens from the genera *Fusarium*, *Tilletia*, *Ustilago*, *Septoria*, and *Erysiphe* were recorded. Disease diagnosis is started in the field by describing the main symptoms and continues with the isolation and identification of the causative agents. For this purpose, generally accepted phytopathological methods were used, and the samples were taken twice

during each phenophase. The assessment was carried out according to SEV (1988) (Score 1 is reported for resistant plants, without attack by pathogens (R - Resistant); Score 3 - plants with necrotic spots on the leaves (S - Sensitive); Score 5 – limited spots on the leaves, with more or less fungal bodies, mycelium development (LS - Low sensitive); Score 7 – extensive, unlimited spots on the leaves, with fruiting bodies of the pathogen, numerous mycelium (HS - High sensitive).

RESULTS and DISCUSSION

Increasingly frequent changes in climate change the conditions of growth and development of plants, which affect the timing of sowing and planting, temperature and humidity of the soil, variety composition, irrigation rates, weeds, diseases and pests. In recent years, heat waves have become more frequent and of higher intensity, which has a negative effect during the reproductive phases and final yields of wheat, and the water content in the soil decreases by more than 10% during the summer months. This statement is also observed in the last 4 years, in which the meteorological conditions in terms of the sum of monthly average temperatures and precipitation differ from the multi-year average values (climatic norm) for the period 1986 - 2005 (Figure 1).

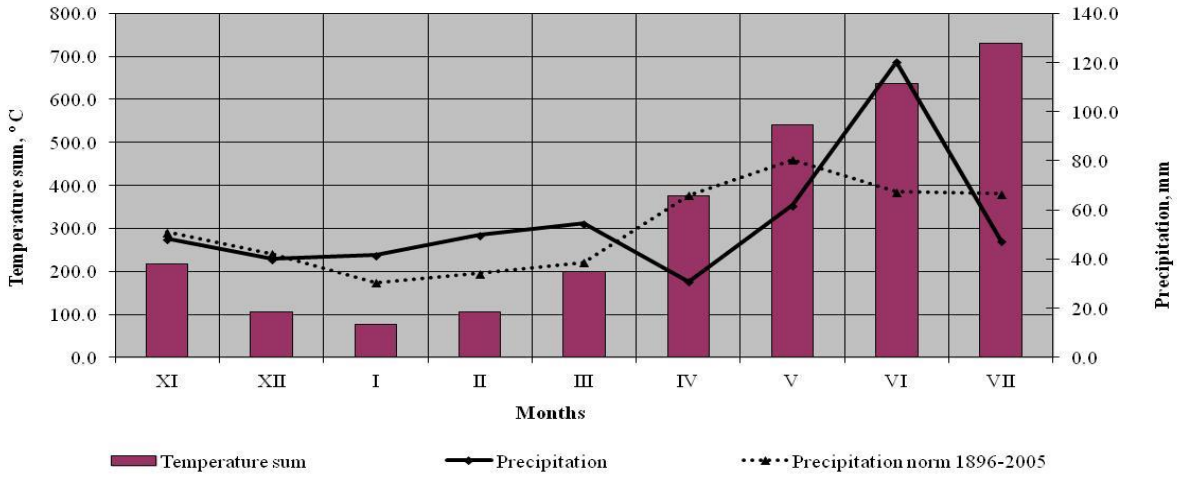

Figure 1. Climatogram, averaged over the period 2018-2021.

During the period 2018-2021, the post-sowing period of wheat is characterized as dry, due to the permanent drought that occurred and the lack of moisture in the 100 cm soil layer. This results in the retention of the initial stages of the wheat vegetation, delaying germination and suppressing the initial growth of young plants. As a result of the drought that has occurred, the wheat is unevenly arranged, which leads to overgrow with weeds and attacks by diseases and pests.

Phytosanitary monitoring of the species composition of weeds in wheat crops shows that the crops are weeded mainly by annual dicotyledonous weeds, the most common being: *Solanum nigrum* L., *Veronica arvensis* L., *Matricaria chamomilla* L., *Capsella bursa-pastoris* L., *Senecio vernalis* W.K., *Erigeron canadensis* L., *Anthemis arvensis* L, *Convolvulus arvensis* L., etc. In the field survey, in 2018-

2021, the species composition differed significantly, and this was due to the differences in weather conditions during the years (Table 1). The greatest diversity was recorded in the economical year 2019-2020, with the year characterized by temperatures and precipitation around the norm.

In 2019-2020, 11 annual dicotyledonous and 4 perennial weeds were reported. In 2018-2019 - 1 annual cereal, 7 annual dicotyledonous and 3 perennial weeds, and in 2020-2021, respectively 9 annual dicotyledonous and 2 perennial weeds. Species such as *Veronica agrestis* L., *Lamium purpureum* L. and *Convolvulus arvensis* L. occur in all three years.

Table 13. Species composition of weeds in wheat crops.

Species	2018-2019	2019-2020	2020-2021
Annual cereal weeds			
Avena ludoviciana Durien.	+		
Annual dicotyledonous weeds			
Chenopodium album L.		+	+
Persicaria lapathifolia L.		+	
Anagalis arvensis L.		+	
Solanum nigrum L.		+	+
Veronica agrestis L.	+	+	+
Stellaria media L.		+	+
Viola tricolor L.	+	+	
Anthemis arvensis L.	+	+	
Capsella bursa pastoris L.	+	+	
Falopia convolvulus L.		+	+
Lamium purpureum L.	+	+	+
Holosteum umbellatum L.	+		
Matricaria chamomilla L.	+		
Bromus arvensis L.			+
Festuca pratensis L.			+
Papaver rhoeas L.			+
Perennial weeds			
Convolvulus arvensis L.	+	+	+
Cirsium arvense L. Scop.	+	+	
Cardaria draba L. Desv.		+	+
Taraxacum officinale L.		+	
Sorghum halepense L.	+		

The total number of weeds, over the years, varied from 1 to 12 pcs./m2 and fresh biomass varied from 4.31 to 45.23 g/m2, and the average for the period was 19.29 g/m2 (Table 2). Compared to other cereal crops and wheat, annual dicotyledonous weeds are the main biological group, their overall importance (as determined by number and biomass importance) being 73%. The established total

number of weeds during the studied years varies on average (CV=21.31%) or as follows - 49 pcs. in the economical year 2018-2019, 58 pcs. in 2019-2020 and 77 pcs. in 2020-2021.

Table 2. Species composition, density and fresh weight of weeds.

Species	2018-2019		2019-2020		2020-2021	
	pcs./m^2	g/m^2	pcs./m^2	g/m^2	pcs./m^2	g/m^2
Annual cereal weeds						
Avena ludoviciana Durien.	6	5.69				
Annual dicotyledonous weeds						
Chenopodium album L.			7	18.56	10	19.56
Persicaria lapathifolia L.			1	6.54		
Anagalis arvensis L.			2	7.26		
Solanum nigrum L.			2	8.32	4	9.42
Veronica agrestis L.	5	14.26	3	14.96	5	15.69
Stellaria media L.			3	13.54	5	14.99
Viola tricolor L.	3	6.89	1	4.31		
Anthemis arvensis L.	5	18.26	3	13.02		
Capsella bursa pastoris L.	4	20.15	2	16.98		
Falopia convolvulus L.			2	17.52	4	16.32
Lamium purpureum L.	3	10.69	4	12.06	6	17.23
Holosteum umbellatum L.	5	19.89				
Matricaria chamomilla L.	3	21.25				
Bromus arvensis L.					5	20.22
Festuca pratensis L.					8	25.32
Papaver rhoeas L.					7	24.99
Perennial weeds						
Convolvulus arvensis L.	8	36.21	10	35.32	12	45.23
Cirsium arvense L. Scop.	5	24.14	4	28.35		
Cardaria draba L. Desv.			9	39.12	11	45.12
Taraxacum officinale L.			5	29.99		
Sorghum halepense L.	2	16.45				

In Figure 2, averaged over the period, the quantitative ratio between the individual groups of weeds is presented. Relative to the total number of weeds, this ratio is 3% for annual cereal weeds, 61% for annual dicotyledonous weeds and 36% for perennial weeds. The mass of reported weeds corresponds to their number, as for annual cereal and dicotyledonous it is respectively 1% and 57%, and for perennial weeds 42%. The degree of weeding in a wheat crop depends on the amount and distribution of rainfall

during the growing season of the crop. The change in the dynamics of weed species in wheat is valid for specific climatic conditions.

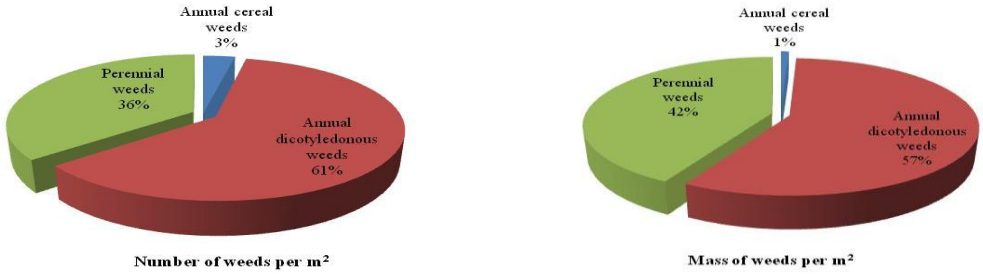

Figure 2. Total number of weeds and mass of weeds, average for 2018-2021.

During the monitoring, insects belonging to the orders Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Neuroptera and Orthoptera were found in the wheat crop. The proportion of the orders to which the insect species belonged in the three years of the study differed in culture.

The total number of insects detected during the three years of the test varied on average (CV=15.63%) – 373 pcs. in 2019, 280 pcs. in 2020 and 372 pcs. in 2021. The distribution by orders and years establishes that the representatives of the order Coleoptera were recorded in the greatest number, and in 2019 the number was twice that reported in 2020 and 2021 (Figure 3). The representatives of the orders Hemiptera and Homoptera are in the next two places in terms of participation in the entomofauna of wheat. In 2019 the representatives of the Homoptera twice outnumbered the representatives of the Hemiptera, in 2020 almost four times and in 2021 the number of representatives of the Hemiptera was one and a half times higher than those of the Homoptera. The representatives of the orders Orthoptera, Lepidoptera and Neuroptera are reported in the smallest numbers, and in some years they are not even reported. The Diptera and Hymenoptera orders showed an increasing trend in numbers over the study period, particularly pronounced in 2021 compared to 2020.

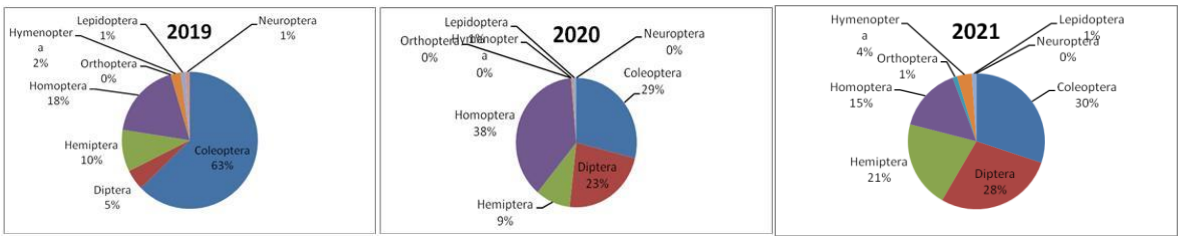

Figure 3. Distribution of insects by orders and years, %.

The main pest, which has the largest and most permanent presence in the entomofauna of wheat, is the *Sitobion avenae* L. *Lema melanopus* L. appeared as a dominant species in two of the three years studied. The *Cicadella viridis* L. retained its participation as a subdominant or minor species in all three

years of the trial, while the Lygus ssp. was permanently present in the wheat entomofauna, albeit as a secondary participant (Table 3).

Table 3. Species composition of the main enemies of wheat.

Species	**Year**		
	2019	**2020**	**2021**
Sitobion avenae L.	**	**	***
Phorbia securis Tiensuu		**	***
Lema melanopus L.	***	***	
Cicadella viridis L.	*	*	**
Chlorops pumilionis Bjerk.			**
Eurygaster integriceps Puton			**
Lema lichenis L.			*
Dolycoris baccarum L.			*
Lygus ssp.	*	*	*
Phyllotreta ssp.	**		**
Legend: *** - dominant species; ** - subdominant species; *- secondary species			

During the three years of the study, among the beneficial species, *Coccinella septempunctata* L., *Hippodamia variegata* Goeze, predatory bugs from the genus *Orius* and *Nabis*, as well as *Cantharis rufa* L., are the most common.

The results of phytopathological observations on the development of economically important diseases, including pathogens of the genera *Fusarium*, *Tilletia*, *Ustilago*, *Septoria*, and *Erysiphe* are presented in Table 4.

On average for the period 2019-2021, the data show that the development of pathogens from the genera *Puccinia* and *Erysiphe* are within the permissible limits, with the affected plant area being 10-25%, and does not affect the spike according to the scale of SEV (1988).

The degree of attack by *Puccinia* sp, varies by year and depends on the climatic conditions of the studied period. Higher levels of sensitivity (5 LS) were observed in 2019. The economical years 2020 and 2021 were characterized as wetter and this led to the development of the pathogen. Wheat showed a higher sensitivity to the tested pathogen (7 HS), due to the created more favorable conditions for its development.

The phytopathological assessment for *Erysiphe* sp. shows that in 2019 the highest attack (7 HS) was recorded in the stalk shooting stage, and in 2020 and 2021 the sensitivity of wheat to the pathogen was manifested in the stages of earing, milk and wax ripeness. The manifested higher sensitivity of wheat to *Erysiphe* sp. is caused by the created favorable climatic conditions for its development.

Climatic conditions in 2019 favored the development of the pathogen *Septoria* sp., which showed higher levels of susceptibility (7 HS) in all four stages of wheat development. In 2020 and 2021, the phytopathological assessment of the crop to the pathogen ranged from grade 3 S to 5 LS.

During the studied period, wheat showed high resistance to the pathogens of *Fusarium* sp. and *Tilletia* sp. (1 R).

Table 4. Phytopathological evaluation of wheat, 2019-2021.

Stages	***Puccinia* sp.**			***Fusarium* sp.**			***Tilletia* sp.**			***Erysiphe* sp.**			***Septoria* sp.**		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**
Stalk shooting	5 HS	7 HS	7 HS	1 R	1 R	1 R	1 R	1 R	1 R	7 LS	1 R	1 R	7 HS	5 LS	5 LS
Earing	5 LS	7 HS	7 HS	1 R	1 R	1 R	1 R	1 R	1 R	1 R	7 HS	7 HS	7 HS	5 LS	5 LS
Milk ripeness	5 LS	7 HS	7 HS	1 R	1 R	1 R	1 R	1 R	1 R	1 R	7 HS	7 HS	7 HS	3 S	3 S
Wax ripeness	5 LS	7 HS	7 HS	1 R	1 R	1 R	1 R	1 R	1 R	1 R	7 HS	7 HS	7 HS	3 S	3 S

Legend: 1 R – Resistant, 3 S-Sensitive, 5 LS - Low sensitive, 7 HS - High sensitive

Conclusion

During the studied period and the specific climatic conditions of the region, the sowing of wheat variety "Venka 1" was of a mixed type of weeding, with the following quantitative ratio between the individual groups of weeds: for annual cereal weeds, the weed density varied up to 6 pcs./m^2, as a percentage relation this makes 3% of the total weeding of the wheat crop. In the case of annual dicotyledonous weeds, weeds with a density of 28 to 54 pcs./m^2 were recorded, and in percentage terms, this is 61% of the total number of weeds. On average for the period, the reported density of perennial weeds varies from 15 to 28 pcs./m^2, and in percentage terms, this is 36% of the total weeding. The degree of weeding in a wheat crop depends on the amount and distribution of rainfall during the growing season of the crop.

The monitoring of the entomofauna during the period 2019-2021 in wheat crops shows differences in the quantitative and qualitative composition of harmful and beneficial insects during the three years of study. The lower total number of pests caught in 2019 compared to other years is due to the weather conditions during the reporting period – rainfall exceeded the norm many times over. Wheat hosts eight insect orders, the most serious economic damage being caused by the *Sitobion avenae* L. All reported pests are at densities below the economic threshold levels. Having sufficient beneficial insects as species composition and density helps achieve this.

Wheat variety "Venka 1" is characterized by high resistance to pathogens from genera *Fusarium* and *Tilletia* and with a higher sensitivity to pathogens than *Puccinia*, *Tilletia* and *Erysiphe*.

The phytosanitary condition of the autumn fields during the survey period is defined as good, and in some places, the appearance of some of the main weeds, pests of cereal crops and phytopathogens, which are below the economic threshold levels, is observed.

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