Species composition of wheat micromycetes

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Abstract. This article presents the findings of a study that was conducted to determine the species and quantitative composition of fungi that were found in the rhizosphere and various organs of wheat that was either healthy or diseased. There were 77 different species of fungi that were isolated from the soil, rhizosphere, and various organs of wheat. Fungi that have been isolated are classified into three classes, three orders, five families, and twenty-three genera. There were eleven different species of fungi that belong to the genus Fusarium that were isolated from the organs (leaves, stems, and roots) of wheat that were affected by root rot. There are 25 different species of fungi that are included in the species composition of healthy plants, which is less diverse.

1 Introduction

Wheat is one of the leading agricultural crops in Uzbekistan after cotton. According to available data, 226.5 million hectares are sown with wheat every year in the world, the yield is 26 c/ha, and the harvest volume is 586.9 million tons. According to FAO, for human needs in countries producing grain and grain products, it is necessary to increase production by 1.6 - 1.8%.

However, irrigated crops often create more favorable conditions for the development of epiphytically dangerous diseases, in particular root rot. Root rot is one of the most common and harmful diseases of wheat. A number of works have been devoted to studying the characteristics of the bioecology of wheat root rot pathogens, elucidating the conditions that promote or limit the manifestation and development of the disease and justifying measures to combat it [1-31].

In this regard, we were given the task of studying the species composition of soil micromycetes found on wheat and in the rhizosphere of both diseased and healthy plants.

Cereal crops are affected by several species of root rot. On winter wheat, cercosporella, ophiodisease, helminthosporium, and fusarium forms of horse rot are found. In areas with sufficient or excessive moisture, pythium, cercosporella, and ophiopathic root rots are usually common, and in arid areas, common or helminthosporium and fusarium root rots predominate [9, 29, 30].

In Uzbekistan, the study of soil fungi was carried out by M.Sh. Sagdullaeva [24, 25], L.K. Goldstein [8], A. Sheraliev, M.A. Zuparov [10], M. Mamiev [16] and others According to these authors, the fungi they isolated belong to the class of imperfect fungi.

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E.A. Klechkovskaya [12], V.V. Kotlyarova, L.M. Makhova [14], V.G. Novokhatka [21], Marin, and others, studying root rot on wheat crops in order to identify phytopathogenic fungi, note that the pathogens are fungi of the genus *Pythium, Fusarium, Helmintosporium, Rhizoctonia*.

Phytopathogenic fungi, the causative agents of root rot, are complex and variable forms; they persist on plant debris and in the soil, and are less often transmitted by seeds.

It is known that among soil fungi in the rhizosphere of plant roots there are many phytopathogenic forms, for example, fungi of the genus *Rhizoctonia* and *Fusarium*.

The accumulation of pathogenic fungi in the soil poses a particular danger to plants. Pathogens of root rot primarily affect weakened plants, so epiphytotic diseases are mainly observed in years unfavorable for the development of cereals. Root rot causes yield reduction and degrades grain quality [3].

2 Materials and Methods.

The degree of plant infestation is determined as a percentage or points, on a 4-point scale [13].

0 – no signs of damage;

1 – at the base of the stem or on its underground part there are brown streaks or narrow stripes;

2 – at the base of the stem or on its underground part there are root strips covering more than half of the surface of the organ;

3 – continuous browning of the first stem and underground internode;

4 – absence of productive stems in the presence of symptoms (score 3).

To study fungi developing directly on the surface of leaves, stems and roots of wheat, the wet chamber method was used [7].

To study the fungi of the wheat rhizosphere, the method of aqueous washes was used [6].

The study of soil fungal flora was carried out according to the method of M.A. Litvinov [15].

The number of fungi primordia was calculated per 1 g of dry soil. Therefore, from the selected samples, simultaneously with sowing, a 10 g sample of soil was taken and dried to a constant weight. The number of grown fungi primordia per 1g of dry soil was calculated using the formula:

$$A = b.\ v.\ g/d;$$

where, A is the number of fungi primordia in 1 g of dry soil;

b - average number of colonies in a dish;

v - the dilution from which the sowing is made;

g - the number of ml of suspension sown into the cup;

d - the weight of dry soil taken for analysis [15].

Cultivation of fungis to determine their species was carried out according to the method of V.I. Bilay [6, 7].

To determine the species identity of the isolated fungi, the following keys were used: M.A. Litvinov, A.A. Milko, V.I.Bilai, N.M.Pidoplichko [6, 7].

3 Results and Discussion

We conducted studies of the species and quantitative composition of fungi in healthy and diseased wheat root rot and its rhizosphere. From Table 1 it can be seen that we have identified 77 species of fungi from various organs of wheat, its rhizosphere and soil. All

isolated fungi belong to three classes, three orders, five families and 23 genera. Their ratio by toxon is presented in Table 1.

Table 1. Systematic position of fungi found on wheat and in its rhizosphere on farms in the Tashkent region

Class	***Order***	***Family***	***Genus***	***Number of species, PC.***
1	2	3	4	5
Zygomycetes	*Mucorales*	*Mucoraceae*	*Actinomucor Schost.*	1
			Mucor Mich.ex Fr.	4
			Rhizopus Ehr.ex Cda	1
Ascomycetes	*Sphaeriales*	*Chaetomiaceae*	*Chaetomium Kunze ex Fr.*	1
Deuteromycetes	*Hyphomycetales*	*Moniliaceae*	*Aspergillus Mich .ex Fr.*	15
			Cephalosporium Cda	2
			Fusidium Lk	1
			Gliocladium Cda	2
			Oospora Wallr.	1
			Penicillium Lk ex Fr.	20
			Rhinocladiopsis Kamyschko	1
			Scopulariopsis Bain	2
			Trichoderma Pers.ex Fr.	2
			Trichotecium Lk	1
			Verticillium Nees ex Lk	2
		Dematiaceae	*Alternaria Nees ex Lk*	3
			Cladosporium Lk ex Fr	2
			Curvularia Boedijn	1
			Helminthosporium Lk ex Fr.	1
			Heterosporium Klotzsch	1
			Stachybotrus Cda	1
		Tuberculariaceae	*Dendrodochium Bonord.*	1
			Fusarium Lk ex Fr.	11

Of the total, the class *Deuteromycetes* seems to be the most diverse, which is represented by 70 species.

Analyzing the data, it should be noted that in terms of species, among the imperfect fungi, the genus Penicillium turned out to be the most numerous - 20 species, then *Aspergillus* - 15 species, *Fusarium* - 11 species, the remaining genera - 1-3 species each.

The table data indicates that in the farms under study, fungi of the genus *Mucor* were most often found from the *Zygomycetes* class. Thus, in terms of species composition, the group of imperfect fungi is the richest, including 70 species. The predominant species among them are the species of the genera *Penicillium, Aspergillus,* and *Fusarium*. Representatives of other groups of fungi are found in small quantities.

Mycoflora of wheat. We examined the roots, leaves and stems of both diseased and healthy wheat plants.

The results of mycological analysis of healthy plants show that the fungal species mainly found on the examined organs are *Actinomucor elegans, Alternaria alternata,*

Aspergillus alliacens, Aspergillus candidus, Aspergillus niger, Aspergillus ustus, Cepholosporium glutineum, Cladosporium ele gantulum, Dendrodochium toxicum, Fusarium avenaceum, Fusarium culmorum, Fusarium gibbosum, Fusarium graminearum, Fisidium viride, Mucor racemosus, Mucor chistioniensus, Mucor circinelloides, Penicillium aurantio virens, Oospora nivea, Penicillium islandicum, Rhizopus nigricans.

Our studies show that micromycetes isolated from healthy wheat plants mainly belong to various genera *Aspergillus, Fusarium, Cladosporium, Mucor, Penicillium,* and *Rhizopus*. In terms of frequency of occurrence, species of the genera *Alternaria, Fusarium, Penicillium* and *Mucor predominate*. A total of 25 species of *micromycetes* have been identified. The data obtained indicate that the species composition of microscopic fungi inhabiting the roots, stems and leaves of healthy wheat is quite diverse and is represented mainly by representatives of the class *Zygomycetes* and *Deuteromycetes*.

Mycological analysis of diseased wheat plants showed that the following species of micromycetes were isolated from the roots, leaves and stems: *Fusarium culmorum, F.oxysporum, F.solani, F.sambicinium, F.var.agrillaceum, F.avenaceum, F.gibbosum, F .graminearum, Helmintosporium sativum, Mucor racemosus, Trichoderma lignorium, Aspergillus flavus, Alternaria alternata, Alternaria tennus, Alternaria flavus, Alternaria ustus, Cepholosporium acremonium, Cladosporium elegantulum, Curvularia intermedia, Fusarium culmorum, Fusarium oxysporum, Fusarium solani, Fusarium moniliforum, Fusarium sambicinum, Fusarium solani, Mucor racemosus.*

Table 2. Species of fungi identified from various organs of healthy wheat.

Species of fungi	Plant organs		
	Root	Leaves	Stem
Actinomucor elegans Eidam	+	-	+
Alternaria alternata (Fr.) Keissl.	+	+	-
A.tenuis Nees	+	-	-
Aspergillus alliaceus Thom et Church	+	-	+
A.candidus Lk ex. Fr.	-	+	-
A. niger v.Tieghem	-	+	-
A.ustus (Bain) Thom et Church	+	-	-
Cephalosporium glutineum Kamyschko	+	-	-
Cladosporium elegantulum Pidopl.et Den.	+	+	+
C. herbarum (Pers.) Lk	+	-	-
Dendrodochium toxicum Pidopl. et Bilai	+	-	+
Fusarium avenaceum (Fr.) Sacc.	+	+	+
F. culmorum (W.G.Sm) Sacc.	+	+	+
F.gibbosum App.et Wr. Emend.Bilai	+	-	-
F. graminearum Schwabe	-	+	+
Fisidium viride Grove	+	-	-
Mucor racemosus Fres.	+	+	+
M. chistioniensis Hagem	+	-	-
Oospora nivea (Fckl) Sacc. E. Vegl.	+	-	-
Penicillium aurantio-virens Biourge	+	-	+
P. islandicum Sopp	+	-	-
P. lividum Westl.	+	+	+

P. notatum West.l	+	+	+
P. purpuragenum Fler. et Stoll	+	+	+
Rhizopus nigricans Her.	+	-	-
Total	23	10	12

Some of these fungi turned out to be the most common, as they were isolated from roots, stems and leaves (Table 2). These are *Alternaria elegans, Aspergillus flavus, Aspergillus ochraceus, Aspergillus ustus, Cladosporium elegantulum*, etc.

Rare species should be called *Verticillium dahliae*, *Penicillium soppi, Penicillium tardum, Penicillium camemberti, Mucor circinelloides, Gliocladium roseum, Fusarium graminearum, Fusarium gibbosum, Actinomucor elegans, As pergillus candidus*, since they are found only on the roots, and were not on the stems and leaves discovered (Table 3).

Table 3. Species of fungi identified from various organs of diseased wheat.

Species of fungi	**Organs of a diseased plant**		
	Root	Leaves	Stem
Actinomucor elegans Eidam	+	-	-
Alternaria alternata (Fr.) Keissl.	+	+	+
A. gossypii(Jacz.) Nisikado	+	-	+
A.tenuis Nees	+	-	+
Aspergillus alliaceus Thom et Church emend. Fennell et Warcup	-	+	+
A.candidus Lk ex. Fr.	+	-	-
A. flavus Lk. ex. Fr.	+	+	+
A. fumigatus Fres.	+	+	+
A. insultus Bain	+	+	+
A. niger v.Tieghem	+	+	+
A. ochraceus Wilhelm	+	-	+
A. rephmii Zuk.	+	-	-
A. petrakii voros	+	+	-
A.spectabilius Christensen et Raper	-	+	-
A. terreus Thom	+	+	+
A. tericola March.	+	-	-
A.ustus (Bain) Thom et Church	+	+	+
A. versicolor (vuill.)Tieraboschi	-	+	+
A. wentii Wehm.	+	-	-
Cepholosporium acremonium Cda	+	-	-
C. glutineum Kamyschko	+	-	-
Chaetomium globosum Kze et Fr.	+	-	-
Cladosporium elegantulum Pidopl.et Den.	+	+	+
C. herbarum (Pers.) Lk ex Fr.	+	-	-
Curvularia intermedia Boedijn	+	-	-
Dendrodochium toxicum Pidopl. Et Bilai	+	-	+
Fusarium avenaceum (Fr.) Sacc.	+	+	+
F. culmorum (W.G.Sm) Sacc.	+	+	+
F.gibbosum App.et Wr. emend.Bilai	+	-	-
F. moniliforme Sheldon	+	+	+
F.oxysporum (Schlecht.) Snyd. et Hans	+	+	+
F. solani (Mart.) App. et Wr.	+	+	+
F. solani (Mart.) App. et Wr.var. argillaceum (Fr.) Bilai	+	-	-
F. sporotrichiella Bilai var.poae (Pk.) Wr.	+	-	-
F. heterosporium Nees	+	-	+
F. sambucinum Fuck.	+	-	+

F. graminearum Schwade	+	-	-
Fusidium viride Grove	+	-	-
Gliocladium roseum (Lk) Bain	+	-	-
G. zaleskii Pidopl.	+	-	+
Helmintosporium sativum	+	+	-
Heterosporium hordei Bub.	+		
Mucor racemosus Fres.	+	+	+
M.sturminus Hagem	-	+	+
M. chistioniensus Hagem	+	-	-
M. circinelloides (v.Thigh.) Migula	+	-	-
Oospora nivea (Fckl) Sacc. et Vegl.	+	-	-
Penicillium aurantio-virens Biourge	+	-	+
P. camemberti Thom	+	-	-
P. cremeo-griseum Chalabuda	-	-	+
P. cinereo-atrum Chalabuda	-	+	+
P.chrzasczii Zal	-	+	-
P. fellutaneum Biorge	-	-	+
P. islandicum Sopp.	+	-	-
P. kapuseinskii Zall.	+	-	+
P. lanoso-coeruleum Thom	-	-	+
P. lividum Westling	+	+	+
P. notatum Westling	+	+	+
P. paraherguei Abe	-	-	+
P. purpuragenum Fler. et Stoll	+	+	+
P. rubrum Stoll	+	+	+
P. soppii Zaleski	+	-	-
P. steckii Zaleski	-	-	+
P. tardum Thom	+	-	-
P. urticae Bain	+	-	+
P.vinaceum Gilman et Abbott.	-	-	+
P. waksmani Zaleski	-	+	-
Rhinocladiopsis versiculosa Kamyschko	+	-	-
Rhizopus nigricans Eherenberg	+	-	-
Scopulariopsis brevicaule v. glabra Thom	+	-	+
S. nigrum Sopp	+	-	-
Stachybotrys alternans Bon	+	-	-
Trihoderma lignorum (Tode) Harz	+	+	+
T. koningii Oud.	+	-	+
Trichothecium roseum Lk ex Fr.	+	-	-
Verticillium dahliae Kleb.	+	-	-
V. lateritium Berk.	+	+	+
Total	64	29	42

The species composition of microscopic fungi isolated from diseased wheat plants is quite diverse. Among the isolated *micromycetes* there are fungi of the genus *Fusarium, Alternaria, Aspergillus, Penicillium, Curvularia, Cladosporium, Trichoderma*, a total of 77 species were identified.

The species composition of healthy wheat plants is less diverse and includes 25 species of fungi.

A comparative analysis of the mycoflora of healthy and diseased plants shows that in both cases there are representatives of the genera *Alternaria, Cladosporium, Fusarium, Trichoderma, Mucor, Rhizopus, Penicillium*, but quantitatively the mycoflora of diseased plants predominates.

Thus, based on the data obtained, we can conclude that various representatives of the genus Fusarium have been isolated from diseased and healthy wheat plants, which apparently cause root rot on many crops, in particular on wheat.

Distribution of fungi in the rhizosphere of healthy and diseased wheat plants.

As a result of the work of many domestic and foreign researchers devoted to the study of the quantitative and species composition of fungi and other microorganisms living in the rhizosphere of higher plants, certain patterns of distribution of microscopic fungi have been identified depending on soil and climatic conditions, the type and physiological state of the plant, the phase of its development, and the season. years and depth of the soil horizon [2, 5, 8, 10, 16, 19, 25, 26, 27].

According to A.F. Korshunov [13] and N. Orazov [22], a decrease in the number of fungi was noted in the rhizosphere of affected plants. In their opinion, this is due to a large accumulation of typical microorganisms in the root zone, in particular bacteria that retard the development of fungi.

According to other authors [2, 25], there was a noticeable increase in the number of soil microscopic fungi in the rhizosphere of affected plants compared to the number of fungi in the rhizosphere of healthy plants.

According to M.A. Zuparov [10], in the rhizosphere of mulberry seedlings affected by wilt, the number of fungi is higher (23.3 thousand in 1 g of dry soil) than in healthy specimens (19.1 thousand).

A study of the relationship between genera and species of fungi in the rhizosphere of healthy and diseased wheat plants showed that the physiological state of the plant significantly affects not only the number, but also the species composition of fungi. In the rhizosphere of wheat plants affected by root rot, compared to healthy ones, there is a noticeable increase in the number of some genera and a decrease in other genera.

In the rhizosphere of diseased plants, the species *Rhizopus nigricans* and *Mucor racemosus* from the family *Mucoraceae* are often isolated, and from the rhizosphere of healthy plants, *Actinomucor elegans, Mucor circinelloides*, and *M.sturminus* are often isolated. In the rhizosphere of wheat, the number of fungi of the genus Fusarium - causative agents of root rot and wilt - increases due to the species *Fusarium oxysporum, F.solani, F. moniliforme, F. solani var. argillaceum*. In the rhizosphere of wheat affected by root rot, *Fusarium oxysporum* and *F.solani* dominated quantitatively. The number of darkly pigmented hyphal fungi in the rhizosphere of diseased wheat plants, in particular the species *Alternaria alternata* and *Cladocporium herbarum*, increases noticeably. In addition to those listed, *Stachybotrus alternans*, *Curvularia intermedia, Helmintosporium sativum*, and *Heterosporium hordei* were isolated from the rhizosphere of affected plants.

In the rhizosphere of plants affected by root rot, a decrease in the number of genera and species diversity of fungi is observed. This change probably occurs due to toxic substances released by plant pathogens.

When comparing the mycoflora and the frequency of occurrence of fungi in the rhizosphere and roots of healthy and sick wheat, it was noted that in the rhizosphere of diseased plants a significantly larger number of fungi were detected than in healthy plants.

From the roots and rhizosphere of healthy wheat, along with widespread species of fungi from the genera *Aspergillus* and *Penicillium*, the species *Chaetomium globosum*, *Fisidium viride, Rhinocladiopsis versiculosa, Trihoderma lignorium, Fusarium culmorum, and F. avenaceum* were isolated.

Thus, the studies showed that in the rhizosphere of wheat affected by root rot, the following species of fungi are found and quantitatively dominate: *Rhizopus nigricans, Aspergillus niger, A.flavus, A.insultus, A.wentii, A.ohraceus, Cephalosporium acremonium, C .glutineum, Cladosporium herbarum, Dendrodochium toxicum, Fusarium oxysporum, F.solani, F.solani var. argillaceum, Gliocladium roseum, G. zaleskii, Helmintosporium*

sativum, Heterosporium hordei, Penicillium purpuragenum, P.soppi, Scopulariopsis brevicaula v. glabra, Stachybotrus alternans, Trichotecium roseum, Curvularia intermedia, Verticillium dahliae, V.lateritium.

Among them there are representatives with varying degrees of parasitism - from saprotrophs to facultative parasites.

F.oxysporum known as the causative agent of *Fusarium* wilt of plants [7]. Fungi of the genera *Alternaria, Cladosporium, Mucor* and some species of *Aspergillus* and *Penicillium* are known as secondary, accompanying organisms.

4 Conclusion

The mycoflora of healthy and diseased wheat root rot was studied and 77 species of fungi were isolated and identified from various organs of diseased wheat, its rhizosphere and soil.

All isolated fungis belong to three classes, three orders, five families and 23 genera.

The species composition of healthy wheat plants is less diverse and includes 25 species of fungi.

Various representatives of the genus *Fusarium* that cause root rot have been isolated from diseased and healthy wheat plants, while fungi of the genera *Alternaria*, *Cladosporium, Mucor* and some species of *Aspergillus* and *Penicillium* are known as secondary, accompanying organisms.

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