Phytopathogenic complex of the genus *Fusarium* in wheat varieties grown in Siberia
Among the most dangerous phytopathogens of grain crops are microscopic fungi of the genus *Fusarium*.

They can be found in all grain-growing regions, including territories with relatively unfavorable soil and climatic conditions for the fungi.

Most species have a wide phylogenetic host specificity, are not strictly limited to the area of the host plant, are able to contaminate grain with toxins when stored and cause damage to various plant organs during the growing season.

The ubiquitous spread, high ecological plasticity, phytopathogenicity of certain species, and rather rapid evolutionary changes determine the prospects for *Fusarium* to be studied. The biodiversity analysis, area and pathogenicity monitoring of dominant species allow one to establish the structure of the phytopathogenic complex in different regions, taking into consideration biotic and abiotic factors.

Despite the large amount of current research, there is little information on the distribution, species composition and harmfulness of *Fusarium* in Siberia. The description of the genus *Fusarium* on the territory of Russia concerns mainly its European and Far Eastern regions.

*Figure 1.* Symptoms of grain damage and morphology of *Fusarium in vitro.*
We have studied the grain and rhizosphere soil from different regions of Siberia, i.e. Central Siberia (Krasnoyarsk Territory, Khakassia, Tyva), Western Siberia (Tyumen and Omsk Regions), Eastern Siberia (Irkutsk Region, Buryatia).

In total, 19 varieties of mid-season soft and hard spring wheat were studied.

The study of the morphological and cultural characteristics of monosporous cultures and subsequent molecular genetic verification have shown that fungi of the genus *Fusarium* in wheat grain are represented by eleven species: *Fusarium avenaceum* (Fr.) Sacc., *Fusarium culmorum* (Wm.G. Sm.) Sacc., *Fusarium diversisporum* Sherb., *Fusarium heterosporum* Nees & T. Nees, *Fusarium oxysporum* Schltdl., *Fusarium poae* (Peck) Wollenw., *Fusarium sambucinum* Fuckel, *Fusarium incarnatum* (Roberge ex Desm.) Sacc., *Neocosmospora solani* (Mart.) L. Lombard & Crous (syn. *Fusarium solani* (Mart.) Appel & Wollenw.), *Fusarium sporotrichioides* Sherb. (current name *Fusarium chlamydosporum* Wollenw. & Reinking), *Fusarium tricinctum* (Corda) Sacc.

Figure 2. Phylogenetic tree of *Fusarium* spp. constructed with ITS regions by maximum likelihood method.
The species composition of *Fusarium* on wheat varieties significantly differed in the presence and ratio of individual species.

The *F. sporotrichioides* is represented as much as possible on the grain of most of the studied varieties: grain contamination varied from 1.5 to 7.5%; the species share in the complex of the genus *Fusarium* ranged from 20 to 67%. In some varieties, a significant increase in the proportion of species *F. oxysporum*, *F. culmorum*, *F. incarnatum*, *F. sambucinum*, *F. avenaceum*, *F. poae*, and *F. tricinctum*.

In the rhizosphere of wheat, *Fusarium* are maximally represented by seven species (*F.avenaceum*, *F. incarnatum*, *F. oxysporum*, *F. sambucinum*, *F. sporotrichioides*, *F. tricinctum*, *N.solani*). The most common were *F. oxysporum* and *F.sporotrichioides*. The abundance maxima in the root zone of wheat were noted at the beginning and end of the growing season (on average, 17.1 and 18.7 ∙ 10^2 CFU.gm^{-1}, respectively).

The features of phytopathogenic complex for various Siberian regions (with a pronounced dominance of *F. sporotrichioides*) were revealed. Wheat grain infection in Western Siberia varied from 9.3 to 22.3%, depending on the variety. A total of 11 species of the genus *Fusarium* have been identified. *F.avenaceum*, *F. poae*, *F. sambucinum*, and *F. incarnatum* (up to 14.4%) infected the wheat grains by more than 10%.

*Fusarium* grain infection in Central Siberia was in the range of 3.3–22.4%. The species composition of *Fusarium* was identical to the Western Siberia samples; however, there was a significant increase of *F. oxysporum* and *F.tricinctum* by 2.3 and 2.6 times, respectively. Wheat varieties growing in Eastern Siberia, being infected with *Fusarium*, ranged 16.3–22.7%; with in total, eight species having been identified. A share of *F. diversisporum* was noted to increase up to 14.7% and *F. oxysporum*, *F. tricinctum* and *N. solani* were absent.
The phytotoxicity of metabolites, obtained in fungi culture in liquid medium, for wheat seeds and seedlings varied significantly within the genus and individual species.

- In most cases, there was a decrease in vitro seed germination compared to the control, so was inhibition of the hypocotyl growth and, further, stem and root system.

- *F. sporotrichioides* and *F. oxysporum* are highly toxic, i.e. the average in vitro seed germination is below the reference value by more than 55%.

- *F. avenaceum*, *N. solani* and *F. culmorum* can be classified as moderately toxic species, with the average in vitro germination versus the control being in the range of 46–55, 56–68 and 53–57%, respectively; other species have been shown to have low phytotoxicity.

- On seven-day-old wheat sprouts, stem inhibition ranged from 3 to 46% relative to control; the main root - from 2 to 73%. Studying phytopathogenicity of the dominant species *F. sporotrichioides* has found out a significant inhibition of wheat seedlings in comparison with the control: 69% of Siberian strains inhibited sprout development by 50–79%; 31% of strains - by 36–49%. The presence of necrotic zones in plant tissue with an intensity from 1.8 to 2.6 (out of 3 possible points) was noted.

- Thus, the *F. sporotrichioides* strains in different regions of Siberia are characterized by high phytopathogenicity and phytotoxicity. Taking into account the wide distribution in grain and rhizosphere soil, the fungi of this genus create a serious danger in wheat crops grown in Siberia.

- According to the studied phytotoxic, pathogenic properties and the frequency of occurrence in the grain and rhizosphere of wheat, the species *F. oxysporum*, *F. culmorum*, *F. avenaceum* and *N. solani* should also be taken into consideration as potentially dangerous.

*Figure 5. Phytopathogenicity of Fusarium sporotrichioides* (the control is shown at the top left on figure 5B).