Fusarium culmorum (Wm. G. Sm.) Sacc. interaction with other root-associated fungi of cereals

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In the roots of cereals and wild plants growing nearby, 48 taxa of micromycetes belonging to 26 genera were identified. Fungi of the genera *Fusarium, Phoma, Rhizoctonia, Talaromyces, Alternaria,* and *Gliocladium* dominated and made up 74.2% of the total amount of isolates. The distribution frequency of *F. culmorum,* one of the most serious cereal pathogen, exceeded 12.4%. The interactions *in vitro* between *F. culmorum* and nine other most widespread root associated fungi were diverse and strongly determined by the species and isolate of fungus. Fungistatic trophic and mutual antagonisms prevailed among the forms of micromycete interaction. *Rhizoctonia* spp., *A. ochraceus*, *C. globosum,* and *T. flavus* were most aggressive towards *F. culmorum*. Inhibiting the growth and aggressiveness of this pathogen, they can influence the pathological process and the damage caused by it.

Key words: *Fusarium culmorum*, root associated fungi, interaction, cereal

INTRODUCTION

Fusarium culmorum (Wm. G. Sm.) Sacc. is a widespread fungal pathogen causing a serious damage to cereals such as wheat, rye, barley, oats. Severe infections result in large yield and quality losses. This fungus is seed-transmitted and soil-inhabitant [1, 2]. Although it may virtually occur alone, in practice, as with most soil pathogens, it occurs in association with other fungi and causes seedling blight, root rot, foot rot and head blight of cereals [3. 4]. *F. culmorum* is also responsible for foot rot and head blight diseases of small grain cereals, grasses, as well as ear and stalk rot of corn [6]. Alongside *Graminea* Juss., a wide range of other plant species are also attacked by *F. culmorum*.

The mixed infections of *Fusarium* spp. and other foot and root rotting pathogens are observed on lesions of the same plant, and they can influence the aggressiveness of each other. The interaction among pathogens participating in the process of root injury is of particular significance for their harmfulness and severity of disease.

The objective of this study was to investigate the interaction of most widespread root associated fungi with *F. culmorum,* and to ascertain the species or isolates of fungi able to influence its growth and aggressiveness.

MATERIALS AND METHODS

The injured plants were collected in 26 localities of different regions of northern Lithuania. Root rot agents were isolated from the roots of cereals (*Secale cereale* L., *Triticum aestivum* L., *Hordeum distichon* L., *Avena sativa* L.) and 26 wild plants growing nearby (*Agropyron repens* (L.) P. B., *Arthemisia vulgaris* L., *Centaurea cyanus* L., *Cirsium arvense* Scop., *Dactylis glomerata* L., *Chenopodium album* L., *C. hybridum* L., *Erigeron annuus* (L.) Pers., *Euphorbia helioscopia* L., *Matricaria maritima* L., *Medicago lupulina* L., *Melilotus albus* Med., *Mentha arvensis* L., *Myosotis arvensis* (L.) Hill, *Plantago major* L., *Phleum pratense* L., *Rumex acetosella* L., *Taraxacum officinale* Weber, *Sonchus arvensis* L., *Trifolium arvense* L., *T. hybridum* L., *T. pratense* L., *T. repens* L., *Tussilago farfara* L., *Vicia angustifolia* Grufb., *V. sativa* L.). In every locality five plants of each species were collected before the harvest time of cereal.

Pure cultures of fungi were isolated employing common methods [7–9] and identified on the basis of their cultural and morphological characteristics [7, 10–13]. The distribution frequency (DF) of separate fungi species and the percentage they made up in the total number of isolates were calculated [14]. Single spore cultures of selected isolates were transferred on malt extract agar medium (MEA) in tubes for preservation and were used in an interaction survey.

Sixty-one most aggressive isolates of nine micromycete species widespread in the roots of the test plants were selected for an investigation of their interaction with six isolates of *F. culmorum*: *Fusarium avenaceum* (Fr.) Sacc. (10 isolates), *F. oxysporum* (Schltdl.) W. C. Snyder et H. N. Hansen (13), *F. sambucinum* Fuckel var. *minus* Wollenw. (7), *Bipolaris sorokiniana* (Sacc.) Shoemaker (6), *Rhizoctonia* spp. (5), *Aspergillus ochraceus* K. Wilh. (3), *Chaetomium globosum* Kunce: Fr. (2), *Gliocladium catenulatum* J. C. Gilman et E. V. Abbott (9), *Talaromyces flavus* (Klöcker) Stolk et Samson (6). The research on the interaction of micromycetes was carried out *in vitro* in dual-plate assay on the MEA, evaluating them after 5, 10, 15, and 20 days of growth. For evaluation of the interaction between micromycetes, forms of the microorganism interaction proposed by I. Babushkina were applied [15].

RESULTS

Forty-eight taxa of root associated micromycetes belonging to 26 genera (*Acremoniella* Sacc., *Acremonium* Link: Fr., *Alternaria* Nees, *Apiosordaria* Arx et W. Gams, *Arthrinium* Kunze:Fr. in Kunze et J. C., *Aspergillus* P. Michel ex Link: Fr., *Bipolaris* Shoemaker, *Cylindrocarpon* Wolllenw., *Chaetomium* Kunze: Fr., *Cladosporium* Link: Fr., *Fusarium* Link: Fr., *Gliocladium* Corda, *Nigrospora* Zimm., *Papulaspora* Preuss, *Penicillium* Link:Fr., *Periconia* Tode: Fr., *Phoma* Sacc., *Rhizoctonia* DC, *Sepedonium* Link: Fr., *Stemphyllium* Wallr., *Ulocladium* Preuss, *Talaromyces* C. R. Benj., *Thielaviopsis* Went, *Trichoderma* Pers.: Fr., *Zygodesmus* Corda, *Zygorrhynchus* Vuill.) were ascertained in the roots of cereal and wild plants growing nearby. Some of them were parasites actively participating in the root injury, or saprotrophes which affect the roots without being the primary cause of this process. Micromycetes of the genera *Fusarium, Phoma, Rhizoctonia, Talaromyces, Alternaria,* and *Gliocladium* were most frequently detected in the roots of investigated plants and made up 74.2% of the total amount of isolates. *Fusarium* dominated among them (43.6% of total number of isolates) (Fig. 1.). Micromycetes of 15 species and 2 varieties of this genus were determined. The number of *F. sambucinum* var. *minus, F. culmorum, F. avenaceum,* and *F. oxysporum* amounted to 69.2% of all *Fusarium* isolates (Fig. 2). *F. culmorum* was one of the most frequently detected micromycetes, making up 19.2% of the total number of *Fusarium* and 8.4% of all isolates. The DF of this fungus reached 12.4%. *F. culmorum* was identified in the roots of all investigated cereals (*Secale cereale*, *Triticum aestivum*, *Hordeum distichon*, *Avena sativa*) as well as in the roots of 11 wild plant species (*Agropyron repens*, *Arthemisia vulgaris*, *Cirsium arvense*, *Dactylis glomerata*, *Chenopodium album*, *C. hybridum*, *Matricaria maritima*, *Plantago major*, *Sonchus arvensis*, *Tussilago farfara*, *Vicia angustifolia*) growing beside. *F. culmorum* was most frequently revealed in the roots of wheat (DF 40.0%), less frequently in the roots of barley (DF 29.7%), oats (DF 28.6%) and rye (DF 17.1%). In the roots of wild plants *F. culmorum* was rarer. Its DF reached only 4.9% and was lower as compared to other most widespread *Fusarium: F. sambucinum* var. *minus* (DF 9.1%), *F. avenaceum* (DF 8.1%), *F. oxysporum* (DF 6.7%).

Distribution of micromycetes and the damage they cause strongly depend upon their interrelations. Results of the investigation on the interaction of *F. culmorum* and nine most widespread root-associated micromycetes participating in the process of root injury and destruction demonstrated that their interrelations are diverse and strongly depend upon the species and the isolate of fungus. Three forms of micromycete interaction were revealed: no impact, fungistatic trophic, and mutual antagonisms. The forms of fungistatic trophic and mutual antagonism interaction prevailed, amounting to 50.8 and 45.9%, respectively. No inferaction between the fungi was revealed only in 3.3% of cases.

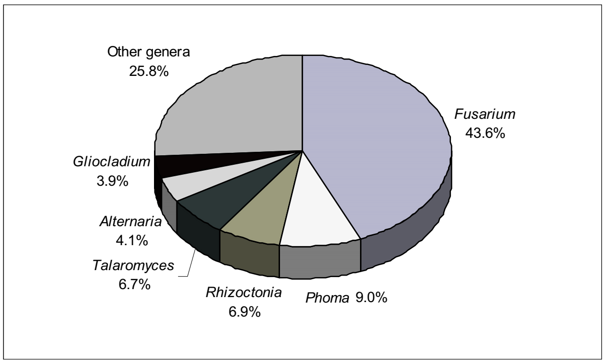

Fig. 1. The distribution of the most widespread root rot agents (% of the total number of isolates)

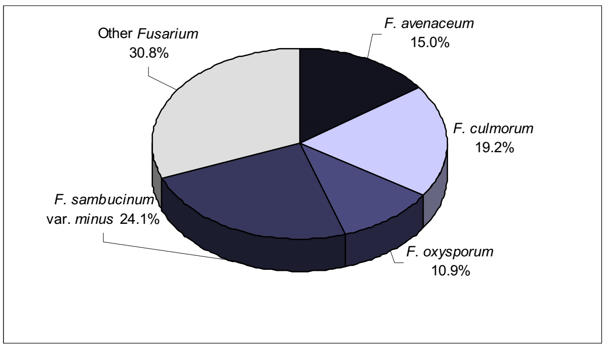

Fig. 2. The distribution of the most widespread *Fusarium* species (% of the total number of *Fusarium* isolates)

The majority of *F. culmorum* and *F. avenaceum* isolates inhibited the growth of each other. Although the growth of *F. culmorum* was more intensive and abundant, *F. avenaceum* in most cases was more aggressive, intensively inhibited the growth of *F. culmorum* mycelium and more or less overgrew it. *F. culmorum* isolates 10230, 10580, 10326 were most resistant to the impact of *F. avenaceum.* The *F. culmorum* isolate 10326 even stopped the growth of some isolates of *F. avenaceum* and almost completely overgrew their mycelium. The mycelium of the *F. avenaceum* isolate 10189 grew sickly at the edge of colonies' contiguity. The *F. culmorum* isolate 10316 was most sensitive towards the impact of *F. avenaceum.* The most evident mutual antagonism was revealed between the *F. avenaceum* isolate 10230 and *F. culmorum* isolates.

The investigated isolates of *F. culmorum* and *F. sambucinum* var. *minus* inhibited the growth of each other. Although their growth slackened, it did not stop, and both fungi overgrew each other. The *F. sambucinum* var. *minus* isolate 10185 was most aggressive towards the *F. culmorum* isolates studied. The most evident mutual antagonism was revealed between the *F. culmorum* isolate 10316 and the *F. sambucinum* var. *minus* isolates.

F. culmorum inhibited the growth of *B. sorokiniana* mycelium. *F. culmorum* isolates 10580, 10302, 10326, abundantly overgrowing most of the investigated *B. sorokiniana* isolates, were more aggressive. The *B. sorokiniana* isolate 10276 was most sensitive and the isolate 10409 most resistant to the impact of *F. culmorum.*

The interaction of *F. culmorum* and *F. oxysporum* depended upon their isolates. The most aggressive *F. culmorum* isolates (10230, 10580, 10302, 10326) overgrew almost all investigated isolates of *F. oxysporum.* Nevertheless, the *F. culmorum* isolate 10398 of weakest aggressiveness was overgrown by almost all investigated *F. oxysporum* isolates.

Most of *Rhizoctonia* spp. isolates inhibited the growth of *F. culmorum* and overgrew its mycelium, which changed the colour and started to decay. Most aggressive was the *Rhizoctonia* sp. isolate 10051, and least aggressive was the isolate 10252. The *F. culmorum* isolates 10398 and 10230 were most resistant towards the impact of *Rhizoctonia* spp.

The isolates of *C. globosum* studied also inhibited the growth of *F. culmorum*. The *C. globosum* isolate 10604 was more aggressive. It stopped the growth of *F. culmorum* and even overgrew the mycelium of some its isolates. The growth of *F. culmorum* mycelium slackened at the edge of colonies' contiguity.

A. ochraceus inhibited the growth of *F. culmorum* and more or less overgrew its mycelium. The F. *culmorum* isolates 10230 and 10580 were most susceptible to the influence of *A. ochraceus.* Their mycelium was overgrown and destroyed. *F. culmorum* isolate 10316 was most resistant towards the impact of *A. ochraceus*; although its growth was stopped, the mycelium was not overgrown. The *A. ochraceus* isolate 10390 was the most aggressive.

When investigating the interaction between *F. culmorum* and *G. catenulatum*, it was observed that at the beginning the growth of *F. culmorum* was more intensive and inhibited the growth of *G. catenulatum* mycelium. Later the growth of *F. culmorum* stopped and *G. catenulatum* began to overgrow it. The most aggressive *G. catenulatum* isolates 10337, 10452, 10235, 10044, 10250 heavily overgrew all investigated *F. culmorum* isolates. The *F. culmorum* isolates 10230, 10580 were most resistant to the influence of *G. catenulatum*.

Similar interactions were ascertained between the isolates of *F. culmorum* and *T. flavus*. At the beginning *F. culmorum* grew more intensively and abundantly, inhibited the growth of *T. flavus* mycelium and overgrew it. After 10 days the growth of *F. culmorum* became slower and stopped; however, the colonies of *T. flavus* continued to grow, overgrew the mycelium of *F. culmorum* and stopped its development. Nevertheless, the growth of *T. flavus* was also slowed down. The colonies of *T. flavus* expanded for only 35–50 mm and were by 60–45% smaller in comparison with the control. The *F. culmorum* isolates 10326 and 10230 most evidently influenced the growth of *T. flavus*. All investigated isolates demonstrated a similar impact on *F. culmorum.*

The results of this investigation indicated that the interaction of *F. culmorum* with other root associated fungi varies and depends on the particular isolate. The aggressiveness of *F. culmorum* was revealed only towards some *F. oxysporum*, *F. sambucinum* var. *minus,* and *B. sorokiniana* isolates. Their more aggressive isolates as well as the investigated isolates of *F. avenaceum, Rhizoctonia* spp., *G. catenulatum, A. ochraceus, C. globosum,* and *T. flavus* inhibited the growth of *F. culmorum* and destroyed its mycelium, heavily overgrowing it. The investigated isolates of *Rhizoctonia* spp., *A. ochraceus, C. globosum,* and *T. flavus* demonstrated the most evident aggressiveness and fungistatic or in some cases even fungicidal impact. These micromycetes, inhibiting the growth and aggressiveness of *F. culmorum*, can influence the pathological process and the damage caused by it.

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FUSARIUM CULMORUM (WM. G. SM.) SACC. IR KITŲ JAVŲ ŠAKNYSE APTINKAMŲ GRYBŲ TARPUSAVIO RYŠIAI

Santrauka

Tirtų javų ir greta augančių spontaninės floros augalų šaknyse identifikuoti 48 taksonai mikromicetų, priklausančių 26 gentims. *Fusarium, Phoma, Rhizoctonia, Talaromyces, Alternaria* ir *Gliocladium* genčių grybai vyravo ir sudarė 74,2% bendro izoliatų skaičiaus. *F. culmorum,* vieno svarbesnių javų patogenų, paplitimo dažnis siekė 12,4%. *F. culmorum* ir 9 dažniausiai augalų šaknyse aptinkamų mikromicetų tarpusavio ryšiai *in vitro* buvo labai įvairūs ir priklausė nuo mikromiceto rūšies bei izoliato: vyravo fungistatinis trofinis ir tarpusavio antagonizmas. Agresyviausi buvo *Rhizoctonia* spp., *A. ochraceus, C. globosum* ir *T. flavus* izoliatai, kurie, stabdydami *F. culmorum* augimą bei mažindami jo agresyvumą, gali paveikti patologinį procesą ir jo daromą žalą.