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Changes in *Fusarium* Link Species Composition From Lithuanian Wheat Grain in Years 2005-2007 to 2011-2013

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Abstract. Changes in *Fusarium* species composition from naturally contaminated spring and winter wheat grain from the years 2005-2007 to 2011-2013 are presented. In general, *Fusarium* infection spring wheat grain was much more frequent than in winter wheat. In 2005-2007 *F. avenaceum* was dominant in both crops, with *F. sporotrichioides*, *F. poae* and *F. culmorum* isolated at lower levels, and *F. graminearum*, *F. tricinctum*, *F. equiseti* and *F. oxysporum* were occasionally found on both spring ant winter wheat. In 2011-2013, *F. avenaceum* lost its dominating status among *Fusarium* isolates in both crops, but the species composition of most frequently isolated fusaria in spring and winter wheat was quite different: *F. graminearum*, *F. sporotrichioides*, *F. culmorum* and *F. avenaceum* constituted the major part of fusaria isolated from spring wheat grain, while in winter wheat *F. poae*, *F. sportotrichooides* and the declining *F. avenaceum* were dominant.
Key words: Fusarium, spring wheat, winter wheat, grain infection.

Introduction

Fungi of genus *Fusarium* are the major plant pathogens of wheat and other small grain cereals, causing *Fusarium* head blight (FHB), root rot and seedling blight. Different *Fusarium* species vary in their contribution to yield loss and, especially, to grain contamination with mycotoxins, as particular species are able to produce mycotoxins of variable plant and animal toxicity levels.

Fusarium avenaceum and to lesser extent *F. poae*, *F. culmorum* and *F. sporotrichioides* were regarded as dominant species in Northern Europe (Uhlig, Jestoi & Parikka, 2007; Yli-Mattila, 2010). Other species, such as *F. equiseti*, *F. oxysporum* and *F. tricinctum* do not constitute a significant part of *Fusarium* isolated from wheat (Kačergius, Drik, Mankevičienė & Suproniene, 2008; Mačkinaitė & Kačergius, 2005; Mačkinaitė, Kačergius, Lugauskas & Repečkienė, 2006; Mankevičienė, Supronienė, Dabkevičius & Mačkinaitė, 2007 ; Supronienė *et al*., 2012). In recent years the situation is changing with *F. graminearum*, one of the most harmful species in regard to mycotoxin production, establishing in the region (Yli-Mattila, 2010).

Fusarium species vary in their distribution, way of spreading, host specificity, pathogenicity level, toxicity to humans and animals, and other biological and ecological characteristics. Therefore, dominant *Fusarium* species in wheat are subject to crop type (spring or winter), crop kind, weather conditions and fungicide usage.

Of the species most often isolated from Lithuanian wheat, *F. avenaceum*, *F. culmorum*, *F. poae*, *F. sporotrichioides* and *F. tricinctum* are commonly found in temperate regions of the world. *F. graminearum*, *F. equiseti* and *F. oxysporum* are considered to be cosmopolitan with no obvious geographical inclinations (Leslie & Summerel, 2006). *F. avenaceum*, *F. equiseti* and *F. tricinctum* are primarily regarded as soil saprophytes or weak pathogens and secondary invaders (Chelkowski, Manka, Kwasna, Visconti & Golinski 1989; Leslie & Summerel, 2006), though *F. avenaceum* is known to cause FHB – one of the most destructive wheat diseases (Kang, Zingen-Sell & Bucjenauer, 2005). Of the rest, only *F. sporotrichioides*is not commonly known to cause FHB, and due to its ability to grow at extremely low temperatures is more likely to be associated with saprophytic way of life and is regarded as a weak pathogen (Leslie & Summerel, 2006). Toxicity is another important trait of *Fusarium* species: *F. tricinctum*, *F. oxysporum* and *F. avenaceum* are not associated with toxicity to humans and animals and lack the *tri5* gene, necessary for production of trichothecene mycotoxins (Tan & Niessen, 2003). Strains of *F. poae* were reported to produce nivalenol (NIV), but their toxicity generally regarded as low (Grabarkiewicz-Szczesna, Foremska, Kostecki, Golinski & Chelkowski, 1999; Leslie & Summerel, 2006). *F. culmorum*, *F. graminearum*, *F. sporotrichioides* and *F. equiseti* are all known as ZEA producers, but there is a significant diversity of synthetized trichothecenes among these species: *F. culmorum* produces DON, *F. graminearum* – DON and NIV, *F. sporotrichioides* – T-2 toxin, and *F. equiseti* – T-2 and NIV (Marasas et al., 1984;

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Kokkonen et al., 2010). Production of mycotoxins results in these species being connected with animal toxicoses, moreover, *F. oxysporum* and *F. equiseti* are known as human pathogens (Goldschmied, Friedman & Block, 1993).

Considering the variable physiological characteristics, the study of changes in *Fusarium* species composition and its connections to environmental conditions and agricultural practices might offer new insights for minimising damage to wheat caused by *Fusarium*.

Materials and Methods

Wheat grain samples: winter and spring wheat grain samples for analyses were collected during harvesting in the years 2005-2007 and 2011-2013 from field trials in Institute of Agriculture and commercial fields in Lithuania. A total of 277 samples was collected. (Table 1).

Grain samples were analysed in Plant Pathology and Protection Department and Laboratory of Microbiology of Lithuanian Research Centre for Agriculture and Forestry.

For the laboratory analyses, grain samples of 1kg were taken and kept in a freezer at -20°C until the conduction of experiments. The agar plate method was used for internal grain infection estimation. Grain was de-frosted up to room temperature and s*urface-sterilized* for 3 minutes in 1 % NaOCl before *plating into* Petri-dishes containing potato dextrose agar (PDA: 250 g potatoes, 10 g glucose, 14 g agar, 1L of distilled water) and incubated for 7–8 days at 25±2ºC in dark (Mathur & Kongsdal, 2003). Fungal grain infection incidence was expressed in percentage. The overgrown *Fusarium* colonies were isolated, purified and identified according to Nelson, Toussoun, & Marasas (1983) and Leslie & Summerell (2006).

Data analysis was done by comparing average values of two 3-year periods: 2005-2007 and 2011-2013.

Results

Dominant *Fusarium* species tend to vary between spring and winter wheat, and 2005-2007 and 2011-2013 year periods. 35.33% of spring wheat grain was infected with *Fusarium* in 2005-2007 (Fig. 1). *F. avenaceum* being clearly dominant species among these isolates, infecting 17.63% of grain (Fig. 2). Other frequently isolated *Fusarium* was 3 to 4 times less abundant: *F. culmorum* was isolated from 5.73% of grain, *F. sporotrichioides* – 4.47%, and *F. poae* – 4.37%. *F. tricinctum* and *F. equiseti* were

Table1

No. of wheat samples collected for analysis each year

Year	No. of spring wheat samples	No. of winter wheat samples
2005-2007	44	102
2011-2013	79	52

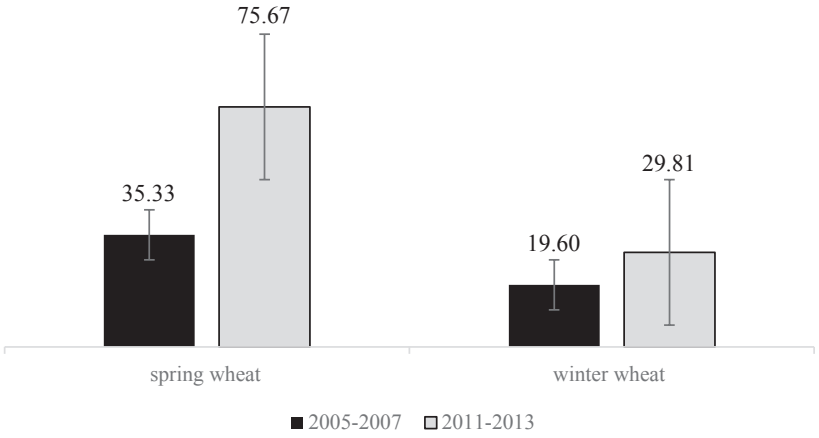

Fig.1. Total count of *Fusarium* infected grain, %.

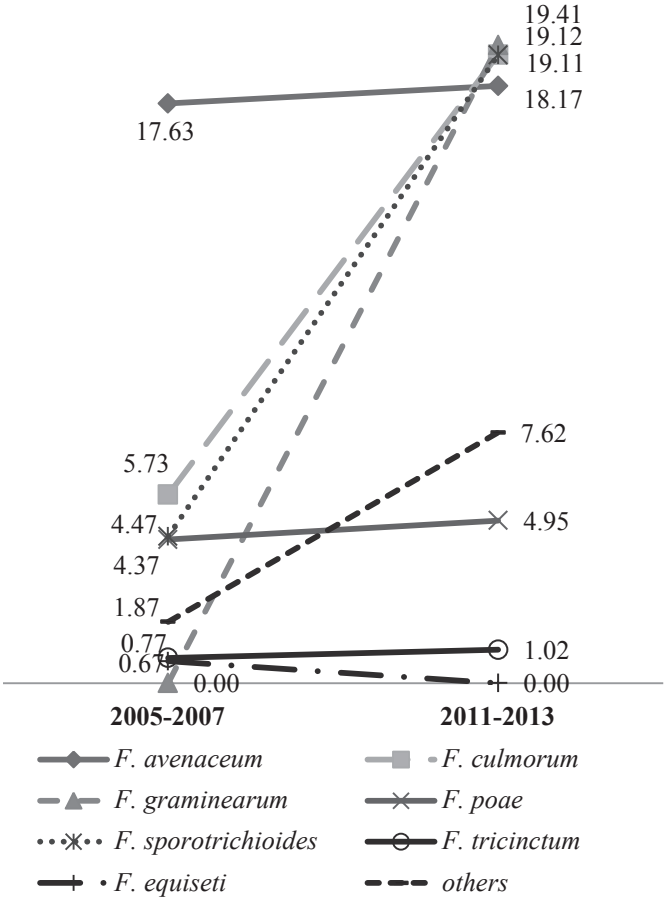

Fig. 2. Changes in *Fusarium* species composition in spring wheat from the years 2005-2007 to 2001-2013,%.

even less common with 0.77% and 0.67% infected grain, respectively. Only solitary *F. oxysporum* and *F. graminearum* isolates were detected in several samples, with overall count of these species being negligible.

In 2011-2013 total part of *Fusarium* infected spring wheat grain increased to 75.67% (Fig. 1). This was mostly conditioned by an increase of *F. graminearum* (up to 19.41% infected grain), *F. sporotrichioides* (19.12%) and *F. culmorum* (19.11%), also the part of unidentified "other" fusaria rose to 7.62% (Fig. 2). Incidence of *F. avenaceum*, *F. poae* and *F. tricinctum* did not change significantly (to 18.17%, 4.95% and 1.02%, respectively), while only very few isolates *F. oxysporum* and *F. equiseti* were detected.

An average of 19.3% of winter wheat grain was infected with *Fusarium* in the years 2005-2007 (Fig. 1). *F. avenaceum* was also clearly dominant species with the incidence of 12.9% grain (Fig. 3). Other species were considerably less frequent: *F. poae* was found on 1.77%, *F. sporotrichioides* – 1.57, *F. culmorum* – 0.57, and *F. tricinctum* on 0.33% of grain. *F. graminearum, F. equiseti* and *F. oxysporum* had very low occurrence. Other species were isolated from 1.97% of grain.

In the years 2011-2013 *Fusarium* fungi were isolated from 29.81% of grain (Fig. 1), the rise in infection incidence in most part associated with the rise of *F. poae* (isolated from 10.17% of grain) and *F. sporotrichioides* (8.14%) (Fig. 3). Incidecne of *F. avenaceum* dropped almost twice to 6.77%. Changes in other *Fusarium* species occurrence were not that drastic: *F. graminearum* increased to 2.2%, *F. culmorum* – 2.16%, *F. tricinctum* – 1.87%, and *F. equiseti* to 0.04% of grain. Incidence of other fusaria on winter wheat grain remained similar as in 2005-2007.

Discussion

An increase in total *Fusarium* incidence from 2005-2007 to 2011-2013 was obvious in both spring and winter wheat, but in spring wheat this rise was

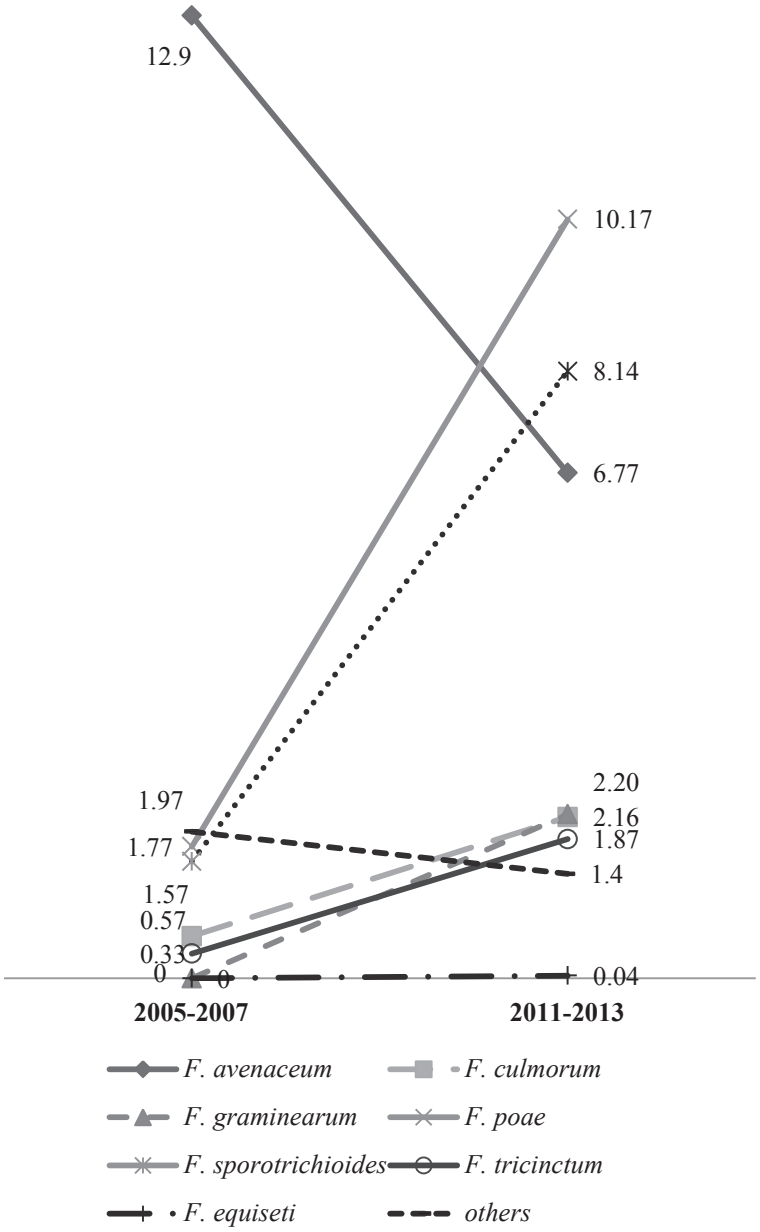

Fig. 3.Changes in *Fusarium* species composition in winter wheat from years 2005-2007 to 2001-2013, %.

especially steep with total count of *Fusarium* infected grain doubling. Generally, *Fusarium* infection level remained much higher in spring than in winter wheat in both time periods: 2005-2007 and 2011-2013.

There was only one dominant *Fusarium* species in both spring and winter wheat in the years 2005-2007, that is *F. avenaceum*. In this regard, the situation was similar to other parts of Northern Europe (Lõiveke, 2006; Treikale, Priekule, Javoisha, & Lazareva, 2010; Uhlig, Jestoi & Parikka, 2007). Other *Fusarium* species had much lower incidence on wheat grain, and the presently dreaded spring wheat pathogen *F. graminearum* was rarely isolated.

The situation changed substantially in the years 2011-2013. In spring wheat grain there were now 4 dominant species of *F. graminearum*, *F. sporotrichioides*, *F. culmorum* and *F. avenaceum*. From agricultural point of view this change in species composition is very adverse, since incidence of fungi associated with toxicoses (*F. graminearum, F. sporotrichioides*and *F. culmorum*) and FHB (*F. graminearum* and *F. culmorum*) rather than those

of weak toxicity and pathogenicity (*F. poae* and *F. avenaceum*) has increased notably, considering the reports of *Fusarium* commonly isolated from wheat in Northern Europe (Yli-Mattila, 2010; Treikale, Priekule, Javoisha, & Lazareva, 2010).

F. poae, F. sporotrichioides and *F. avenaceum* could be regarded as dominant species in winter wheat in the years 2011-2013, although last one is in decline. Considering also that increase in overall incidence of *Fusarium* is slower than in spring wheat, the situation with winter crops seems somewhat better: there is only one reportedly toxigenic species of *F. sporotrichioides* among 3 dominant, and the incidence of only species commonly associated with FHB, *F. avenaceum*, is falling. The rise in incidence of toxigenic *Fusarium* in winter wheat was relatively slow, and the part of grain infected with unknown *Fusarium* species is not increasing – it could mean that no new kind of *Fusarium* infection is spreading in these crops.

Conclusions

1. The pattern of *Fusarium* species composition between periods of years 2005-2007 and 2011-2013 changed substantially in both spring and winter wheat with one dominant species of *F. avenaceum* being replaced by several dominant species.
2. An obvious increase of *F. sporotrichioides* was recorded in both spring and winter wheat between 2005-2007 and 2011-2013, while incidence dynamics of other species was dissimilar between spring and winter wheat.
3. Incidence increase of both total *Fusarium* and particular species was notably lower in winter wheat than in spring wheat.
4. Incidence increase in total *Fusarium* counts in spring wheat was in major part contributed by phytopathogenic and toxigenic species: *F. graminearum*, *F. sporotrichioides*, *F. culmorum*, while in winter wheat – by relatively weak pathogens and toxin producers: *F. avenaceum*.

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