Occurence of *Fusarium* head blight of wheat in Slovakia under the natural infection

Výskyt fuzariózy klasov pšenice na Slovensku v podmienkach prirodzenej infekcie

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Abstract

Occurrence of *Fusarium* head blight (FHB) was documented during two consecutive years in June 2011-2012 under the natural conditions in winter wheat (*Triticum aestivum* L.). Observations were conducted at six different localities in four climatic regions in Slovakia. Incidence and severity of FHB were evaluated at the end of flowering stage in three replications. Each replication contained 100 spikes. These data served as a basis for FHB index calculations. Obtained FHB index values indicated that the environmental conditions of the year 2011 were more favourable to the development of FHB infection. Higher FHB index values were reached at localities with precipitation higher than 100% of long-term average. Although significantly higher incidence of heads with FHB symptoms was recorded in climatic region 02 – quite warm, dry, hilly, correlation between the climatic regions was not confirmed. Except of the climatic conditions, the FHB development can be influenced by nitrogen application. The highest levels of FHB index was in coincidence with the highest and the lowest nitrogen rates applied. In all other cases, the effect of the mineral nutrition on head blight attack was unclear. Analyses of nitrogen forms applied revealed that nitrogen forms had no impact on FHB index value.

Keywords: climatic conditions, Fusarium head bligh index, nitrogen forms, precipitation, winter wheat

Abstrakt

Výskyt fuzariózy klasov pšenice ozimnej (*Triticum aestivum*) v podmienkach prirodzenej infekcie bol sledovaný v júni 2011 a 2012. Sledovanie výskytu sa uskutočnilo na šiestich lokalitách patriacich do štyroch rôznych klimatických regiónov Slovenska. Frekvencia a intenzita napadnutia pšenice furariózou klasu sa hodnotila v rastovej fáze koniec kvitnutia. Na každej lokalite sa hodnotilo sto klasov v troch opakovaniach. Údaje získané hodnotením porastov tvorili podklad pre výpočet indexu fuzariózy klasov (FHB index). Z hodnôt indexu fuzariózy klasov vyplýva, že v roku 2011 boli environmentálne podmienky vhodnejšie pre výskyt fuzariózy klasu ako v nasledujúcom roku. Vyššie hodnoty FHB indexu boli zaznamenané na lokalitách, na ktorých boli úhrny zrážok vyššie ako 100% dlhodobého priemeru. Najvyšší výskyt FHB bol zaznamenaný v klimatickom regióne 02 – dostatočne teplý, suchý, pahorkovitý región, ale korelácia medzi výskytom fuzariózy klasov a klimatickými regiónmi sa nepotvrdila. Okrem klimatických podmienok môže výskyt fuzariózy klasov ovplyvniť aj hnojenie dusíkatými hnojivami. Najvyššia hodnota FHB indexu bola zaznamenaná na lokalite, kde boli aplikované najnižšie a najvyššie dávky dusíka. Vo všetkých ostatných prípadoch bol vplyv hnojenia na výskyt fuzariózy klasov nejednoznačný. Analýzou foriem dusíka v aplikovaných hnojivách sa nezistil žiadny vplyv aplikovanej formy dusíka na hodnotou FHB indexu.

Kľúčové slová: formy dusíka, Index fuzariózy klasov, klimatické podmienky, ozimná pšenica, zrážky

Detailný abstrakt

Fuzariózy klasov patria medzi hospodársky významné choroby obilnín znižujúce ich úrodu, kvalitu osiva a kvalitu zrna určeného tak pre potravinárske ako aj krmovinárske účely v dôsledku kontaminácie mykotoxínmi. K vzniku infekcie dochádza počas kvitnutia za vhodných vlhkostných a teplotných podmienok. Preto cieľom výskumu bolo zistiť vplyv klimatických regiónov na výskyt fuzariózy klasov pšenice v podmienkach prirodzenej infekcie. Výskyt fuzarióz sa sledoval v júni 2011 a 2012 na šiestich lokalitách (V. Úľany, Špačince, Šalov, Soblahov, Jacovce, Sklabiná) patriacich do štyroch rôznych klimatických regiónov Slovenska (00 – veľmi teplý, veľmi suchý nížinný, 01 – teplý, veľmi suchý, nížinný, 02 – dostatočne teplý, suchý, pahorkatinový, 04 – teplý, veľmi suchý, kotlinový, kontinentálny). Frekvencia a intenzita napadnutia pšenice furariózou klasu sa hodnotila v rastovej fáze koniec kvitnutia. Na každej lokalite sa hodnotilo sto klasov v troch opakovaniach. Údaje získané hodnotením porastov tvorili podklad pre výpočet indexu fuzariózy klasov (FHB index). Z hodnôt indexu fuzariózy klasov vyplýva, že v roku 2011 boli environmentálne podmienky vhodnejšie pre výskyt fuzariózy klasu ako v nasledujúcom roku. Vyššie hodnoty indexu fuzariózy klasov boli zaznamenané na lokalitách, na ktorých boli úhrny zrážok vyššie ako 100% dlhodobého priemeru. Najvyšší index bol zaznamenaný v Soblahove v júni 2011 – na lokalite s najnižšími priemernými teplotami a najvyšším úhrnom zrážok (klimatický región 02). V nasledujúcom roku sa najvyššie hodnoty zaznamenali na oboch lokalitách patriacich do klimatického regiónu 02 (Soblahov a Jacovce) a na lokalite nachádzajúcej sa v klimatickom regióne 04 (Sklabiná). Napriek tomu sa korelácia medzi výskytom fuzariózy klasov a klimatickými regiónmi nepotvrdila. Okrem klimatických podmienok môže výskyt fuzariózy klasov ovplyvniť aj hnojenie dusíkatými hnojivami. Najvyššia hodnota FHB indexu bola zaznamenaná na lokalite, kde boli aplikované najnižšie a najvyššie dávky dusíka. Vo všetkých ostatných prípadoch bol vplyv hnojenia na výskyt fuzariózy klasov nejednoznačný. Analýzou foriem dusíka v aplikovaných hnojivách sa nezistil žiadny vplyv aplikovanej formy dusíka na hodnotou FHB indexu.

Introduction

Fusarium head blight, caused by fungi of the genus *Fusarium* spp., is an economically devastating disease of wheat and other small grain cereal crops worldwide (Gilbert and Tekauz 2000, Lori et al., 2003) including Slovakia.

The major *Fusarium* species known to cause *Fusarium* head blight (FHB) are *F. avenaceum, F. culmorum, F. graminearum, Microdochium nivale* (Parry et al., 1995; Xu et al., 2005, Hudec, 2006). Infection by *Fusarium* species on cereal heads may result in reduced overall crop yield (Goswami and Kistler 2004), reduced grain (Nightingale et al., 1999; Snijders, 2004) and seed quality (Winson et al., 2001), and of greatest health concern, contamination of grains with mycotoxins (Desjardins, 2006). The main sources of inoculum consist of splash-dispersed conidia originating from infected crops of preceding crop still present in the field. *Fusarium* spp. and *M. nivale* infect wheat ears primarily during anthesis (Landschoot et al., 2011) and the infection is particularly favoured by conditions of high humidity and warm temperatures (Parry et al., 1995; Chen et al., 2000; Lu et al., 2001).

In view of this interaction, the aim of our research was to examine the influence of climatic regions on FHB occurrence under natural infections in large scale on-farm plots during a two – year's period.

Materials and Methods

Evaluations of the severity and incidence of *Fusarium* head blight (FHB) symptoms were carried out in June 2011 and 2012 at six localities in four climatic regions of Slovakia (Tab. 1). Three replications of groups of winter wheat spikes (*Triticum aestivum* L.) containing 100 spikes were evaluated for the incidence and severity of natural infection at the end of flowering stage – BBCH 69. Subsequently, the disease severity and incidence was expressed as the FHB index. Incidence was evaluated by recording the portion of infected heads. The modified scale of Mielke (1988) was used for the evaluation of FHB severity (Tab. 2).

Table 1 Climatic region and soil characteristics (Linkeš et al., 1996) of evaluated localities in Slovakia

Tabuľka 1 Klimatická a pôdna charakteristika (Linkeš et al., 1996) hodnotených lokalít na Slovensku

Code of climatic areas	Localities	Coordinates	Sum of average daily temperature ≥ 10°C	Rainfall VI – VIII [mm]	Average temperature [°C]		Soil type
					January	Vegetation period	
00 Very warm, very dry, lowland	V. Úľany	48°10´50´´N 17°28´55´´E	>3000 (3230 - 3000)	200	-3	16 - 17	Chernozem
01 Warm, very dry, lowland	Špačince	48°27´21´´N 17° 36´44´´E	3000 - 2800	200 - 150	-4	15 - 17	Chernozem
	Šalov	48°02´40´´N 18°39´23´´E					Regosol, brown soil
02 Quite warm, dry, hilly	Soblahov	48°51´47´´N 18°04´14´´E	2800 - 2500	150 - 100	-4	15 - 16	Gleyic fluvisols
	Jacovce	48°35´38´´N 18°08´05´´E					Brown soil
04 Hot, very dry, hollow basin	Sklabiná	48°07´27´´N 19°21´22´´E	3030 - 2800	200 - 100	-6	15 - 16	Brown soil

Table 2 Evaluation scale of FHB severity (Mielke, 1988)

Tabuľka 2 Stupnica na hodnotenie poškodenia klasu fuzariózou (Mielke, 1988)

Level of damage	% Infected heads
0	0% (no visual symptoms)
1	≤ 5% infected heads
2	5.1 – 10 % infected heads
3	10.1 – 25 % infected heads
4	25.1 – 50 % infected heads
5	50.1 – 75 % infected heads
6	Over 75 % infected heads

FHB index was calculated by using formula of Haidukowski et al. (2005):

$$\text{index}_{FHB}\ (\%) = \frac{\Sigma(a.b).100}{K.6}$$

a – number of heads with the same symptoms

b – level of damage

K – total number of evaluated heads

6 – the highest level of damage

All above mentioned parameters (incidence, severity and FHB Index) were calculated for each observed locality. The agronomic practices performed every year were similar. Winter wheat crops were grown under the conventional tillage practices. Wheat varieties, maturity, susceptibility to *Fusarium* head blight, seed rates and preceding crops are summarized in the Tables 3-4. Weeds, insects and pathogens were controlled with recommended chemicals. Nitrogen fertilizers were applied in spring. Nitrogen content and its forms were calculated based on data sheets released by producer. Meteorological data were obtained from the Slovak Hydrometeorological Institute.

Statistical analysis

Number of infected heads in each locality during observed years was compared with statistical analysis. Data were performed by analysis of variance (one-way ANOVA), using Statgraphics Centurion XV.I. A probability value of $P < 0.05$ was considered to denote a statistical significance difference.

Table 3 Characteristics of the wheat varieties grown in 2011, seed rates and preceding crops

Tabuľka 3 Charakteristika odrôd pšenice pestovaných v roku 2011, výsevky a predplodiny

Locality	Variety	Maturity	Susceptibility to *Fusarium* spp.	Seed rate (seeds*m^{-2})	Pre-crop
V. Úľany	Alacris	Early	No data available	530	Poppy seed
Špačince	Astardo	Medium early	No data available	350	Sugar beet
Šalov	Bardotka	Medium early	High	430	Lens
Soblahov	Baskerville	Late	Medium	430	Soybean/potato
Jacovce	Bohemia	Medium early	Medium	420	Sugar beet
Sklabiná	Garaboly	Early	Medium	520	Winter wheat

Table 4 Characteristics of the wheat varieties grown in 2012, seed rates and preceding crops

Tabuľka 4 Charakteristika odrôd pšenice pestovaných v roku 2012, výsevky a predplodiny

Locality	Variety	Maturity	Susceptibility to *Fusarium* spp.	Seed rate (seeds*m^{-2})	Pre-crop
V. Úľany	Bertold	Medium early	No data available	420	Poppy seed
Špačince	Antonius	Medium early	High	420	Lucerne
Šalov	Federer	Late	High	430	Fallow
Soblahov	Mulan	Medium early	Medium	400	Maize
Jacovce	Karolinum	Medium early	Medium	440	Rapeseed
Sklabiná	GK Bétadur	Medium early	Medium	520	Maize

Results and Discussion

The total FHB index calculated for the six localities observed in June 2011 and 2012, reached the value of 3.3 and 2.2 respectively. Higher precipitations in 2011, which are critical for FHB development (Parry et al., 1995; Chen et al., 2000; Lu et al., 2001) resulted in a higher FHB index value (Tab. 5-6). Based on these results we can conclude that the 2011 year's environmental conditions favoured more to the development of FHB than the following one´s.

In line with these data, we recorded higher values of FHB index in 2011 (0.22 – 6.94) than in 2012 (0.00 – 5.11) (Tab. 5-6). Higher FHB index values were reached at localities with higher precipitation when comparing long-term average (more than 100 % of long term average). The highest FHB index - 6.94 was observed during the first year in Soblahov, where the lowest average temperature and one of the highest precipitation rates were recorded (Tab. 5). The high FHB index value was probably a result of above mentioned climatic factors together with the late maturing wheat variety, which are tend to be more susceptible to *Fusarium* head blight disease (Parry et al., 1995), and soybean as a preceding crop, that residues serves as an inoculum source (Pioli et al., 2000). These data were not confirmed during the following year; however the highest FHB index occurred in Jacovce, in the same climatic region - 02 (quite warm, dry, hilly) (Tab. 6). Correlation between the climatic regions was not confirmed, although significantly higher incidence of heads with FHB symptoms was recorded in climatic region 02 in Soblahov (Tab. 7).

Concerning the climatic conditions, the locality Jacovce in 2011 was only exception where we observed the lowest FHB index value in spite of high precipitation (147 % of the long-term average) (Tab. 5). Based on these disparities we can conclude, that precipitations cannot be considered as the only determining factor of *Fusarium* head blight severity and incidence. Its incidence can be influenced by the already mentioned maturation date (Parry et al. 1995), mineral nutrition, sowing date, canopy density, soil cultivation, preceding crop and chemical treatment (Champeil et al., 2004). In the case of locality Jacovce, we do not suppose the effect of preceding crop (sugar beet) or maturity wheat variety (medium early) as the reason. These factors, along with precipitation are comparable with e.g. Špačince, where the value of FHB index was one of the highest (Tab. 5). The reason of these incompatibilities can be found in local environmental condition and perhaps in cultivar used. Lorri et al. (2009) found out that in Argentina, in years favourable for high occurrence and epidemic of FHB, cultivar Buck Pronto had significantly higher value of FHB index (6.47) than Buck Brasil (0.54). Their research revealed significant differences in FHB development under the conventional tillage and no tillage treatments in favour of the latter; and fertilizer treatments with the highest disease incidence when urea was applied at rate 30 kg N*ha^{-1} at sowing and the same amount at growth stage - Zadoks 29. However the first year observations were not confirmed during the next year.

Table 5 Effect of climatic condition to FHB index in June 2011, Slovakia

Tabuľka 5 Vplyv klimatických podmienok na index fuzariózy klasu v júni 2011 na Slovensku

Locality	Climatic characteristics of June 2011				Head affected (%)	FHB index (%)	x±s	P value
	Average air temperature (ºC)		Average precipitation					
	June	Deviation from the long-term average *	June (mm)	Long-term average (%) [a]				
V. Úľany	20,1	1,8	77	107	16,3	4.59	0,16±0,37	
Špačince	18,8	1	142	195	11,0	4.89	0,11±0,31	
Šalov	18,9	2,1	78	93	9,0	1.94	0,09±0,29	
Soblahov	18,4	-	132	153	29,0	6.94	0,29±0,45	
Jacovce	19,8	1,6	102	146	1,3	0.22	0,01±0,11	
Sklabiná	19,5	1,2	80	99	6,7	1.5	0,07±0,26	0.0093

[a] 1951 - 1980

Table 6 Effect of climatic condition to FHB index in June 2012, Slovakia

Tabuľka 6 Vplyv klimatických podmienok na index fuzariózy klasu v júni 2012 na Slovensku

Locality	Climatic characteristics of June 2012				Head affected (%)	FHB index (%)	x±s	P value
	Average air temperature (ºC)		Average precipitation					
	June (ºC)	Deviation from the long-term average *	June (mm)	Long-term average (%) [b]				
V. Úľany	21,4	3,1	45	63	0	0	0± 0	0.0002
Špačince	20,6	2,8	40	55	0,3	0.06	0,003±0,06	
Šalov	20	-	47	56	7,7	1.56	0,077 ±0,27	
Soblahov	19,1	1,8	118	137	13,3	3	0,15±0,36	
Jacovce	20,8	2,6	75	107	15,3	5.11	0,13±0,34	
Sklabiná	20,1	1,8	58	72	13,7	3.22	0,14±0,34	

[b] 1951 - 1980

Table 7 Average number of heads with FHB symptoms in June 2011-2012, Slovakia

Tabuľka 7 Priemerný počet klasov napadnutých fuzariózou v júni 2011-2012 na Slovensku

Climatic region	Localities	LS Mean
00	V. Úľany	8.17a
01	Špačince	5.5a
	Šalov	8.33a
02	Jacovce	8.33a
	Soblahov	21.17b
04	Sklabiná	10.17a

The disease development can be influenced by nitrogen application. Looking in more detail on mineral nutrition it appeared that in both observed years, the highest levels of FHB index was in coincidence with the highest and the lowest nitrogen rates applied (Tab. 8). These results are in consistence with the findings of the other authors who claims that incidence of *Fusarium* head blight increases when plants suffering from lack of nitrogen (Snoeijers et al., 2000) or are grown in soil with high nitrogen concentration (Martin et al., 1991; Lemmens et al., 2004). In all other cases, the effect of mineral nutrition on head blight attack in our experimental plots was unclear (Tab. 8). According to the several studies, disease incidence can be influenced by the form of nitrogen. Analyses of nitrogen forms applied ($N – NO_3^-$; $N – NH_4^+$; $N – NH_2$) did not revealed any correlation (Tab. 8) although according to the literature urea appears to reduce the *Fusarium* head blight level more than ammonium (Teich, 1989; Lazarovits, 2001). One of the hypotheses to explain this difference in nitrogen form is that urea may increase the number of antagonistic actinomycetes (Huber and Watson, 1974; Waidehi, 1973). No additional fertilizers were applied to observed plots during anthesis. Fertilizers application during this stage tends to increase the percentage of infected seeds. Thus, nitrogen topdressing during anthesis recommended for increasing the N content in grain means a risk, and is not advised (Burgt et al., 2011).

Table 8 Effect of nitrogen rate on FHB index in wheat, Slovakia, 2011-2012

Tabuľka 8 Vplyv dávok dusíka na index fuzariózy klasov pšenice, Slovensko, 2011-2012

Locality	2011					2012				
	N total	N – NO_3^-	N – NH_4^+	N – NH_2	FHB	N total	N – NO_3^-	N – NH_4^+	N – NH_2	FHB
V. Úľany	85,5	31,5	31,5	22,5	4,59	85,5	31,5	31,5	22,5	0
Špačince	200,7	33,5	79,4	87,75	4,89	156,8	22,5	43,7	90,6	0,06
Šalov	165	82,5	82,5	0	1,94	165,0	82,5	82,5	0	1,56
Soblahov	57,6	17,4	31,8	0	6,94	55,0	27,5	27,5	0	3,00
Jacovce	154,7	30,3	63,3	7,5	0,22	197,1	44,8	67,5	34,9	5,11
Sklabiná	71,6	16,2	31,4	23,97	1,5	29,8	6,0	6,0	17,8	3,22

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