ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 107, No. 1 (2020), p. 49–54
DOI 10.13080/z-a.2020.107.007

Resistance against Fusarium head blight in oats

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Abstract

Twenty-nine common oat (*Avena sativa* L.) cultivars were used for Fusarium head blight (FHB) resistance assessment during 2015–2017. The cultivars evaluated for FHB resistance were planted in hill plots (sowing into 15 cm circles 25 cm apart) in three replications and two variants (infected and uninfected). The plants were inoculated with a conidial suspension consisting of a mixture of *Fusarium poae*, *F. graminearum* and *F. culmorum*. The visual symptom score (VSS) was evaluated 14 days after inoculation. Yield tolerance to infection was determined by percentage reduction relative to non-inoculated control for the traits thousand grain weight (TGWR) and grain weight per panicle (GWPR). Seeds from infected spikes were analysed for deoxynivalenol (DON) as well as T-2 plus HT-2 toxin contents. It was found that determination of mycotoxin content in grain is necessary in order to fully describe the state of resistance against FHB in oats. Naked oat (*A. nuda* L.) cultivars were found to have higher resistance levels for all the tested traits and also lower concentrations of mycotoxins. Naked oat cultivars 'Kamil', 'Tibor', 'Izak', 'Otakar', 'Vjatskii', OA 504-6, 'Saul', 'Avenuda', 'Gana' and 'Aldan' showed higher levels of resistance against FHB for of all the evaluated traits. The lowest concentration of DON was determined in the cultivar 'Vjatskii'. The weather conditions significantly influenced the development of infection in individual years and traits related to FHB resistance.

Key words: *Avena sativa*, cultivars, *Fusarium* spp., mycotoxins, resistance.

Introduction

Oats, and especially naked oats, are regarded as desirable for human consumption due to their high nutritional value (Redaelli et al., 2009). Oats are particularly appreciated for grain quality and modest growing requirements (Spasova et al., 2017). Fusarium head blight (FHB) is a fungal disease of oats viewed in recent years as increasingly important internationally (Gagkaeva et al., 2013) and is recognized to be a major threat in oat production (Clear et al., 1996; Yan et al., 2010). Mycotoxins produced by many *Fusarium* species accumulate in the infected grains under favourable conditions (Jestoi et al., 2008; Medina, Magan, 2011), persist in the processed products, and can cause immunosuppression and various health issues in humans and animals (Fredlund et al., 2010).

Oats can be infected by a complex of *Fusarium* species, whose composition and proportions vary considerably among years and regions (Šliková et al., 2010). The findings of Nedomová et al. (2008) reveal that though the infection is not necessarily visible on oats during the growing season, the *Fusarium* species are common to attack the crop under favourable climatic conditions and contaminate it by their toxic products. *Fusarium poae* can produce trichothecenes of type A, such as T-2 plus HT-2, among others (Thrane et al., 2004). The most important *Fusarium* mycotoxin worldwide is the trichothecene deoxynivalenol (DON) (Parry et al., 1995), produced by such species as *F. graminearum* and *F. culmorum*. Most studies of oat resistance to FHB employ inoculations with *F. graminearum* or *F. culmorum* (Bjørnstad, Skinnes, 2008; Šliková et al., 2008; Warzecha et al., 2012). Tekle et al. (2012) have reported that oats are most susceptible to *Fusarium* infection during anthesis and that this susceptibility decreases as plants develop and mature. The duration of the risky flowering period is longer in oats compared with wheat and barley (Tekle et al., 2018). It has been demonstrated that oats are susceptible to primary infection during anthesis. In oats infections occur on a single-spikelet basis and infections rarely spread from spikelet to spikelet because of the long rachilla and rachis of the oat panicle (Tekle et al., 2012).

The few available studies show that resistance to FHB in common oat (*Avena sativa* L.) is a quantitative trait controlled by many genes with low to medium effect (He et al., 2013). Bjørnstad and Skinnes (2008) and Loskutov et al. (2017) have reported that resistant wild oat (*Avena sterilis* L.) and other germplasm may be used in breeding as new sources of resistance against mycotoxin accumulation. A number of measures are needed at different levels in order to prevent the occurrence of mycotoxins at levels considered harmful to human health, and one of the important measures is breeding for resistance (Lacko-Bartošova et al., 2017). Great attention is devoted to obtaining strong disease

Please use the following format when citing the article:
Chrpová J., Palicová J., Štěrbová L., Trávníčková M., Dumalasová V., Chourová M. 2020. Resistance against Fusarium head blight in oats. Zemdirbyste-Agriculture, 107 (1): 49–54. DOI 10.13080/z-a.2020.107.007

resistance in addition to good yield performance and nutritional value, because oats are often grown under low-input or organic farming conditions.

The objective of this study was to present three year results of field experiments in which resistance of oat cultivars to accumulation of mycotoxins (DON and T-2 plus HT-2 toxins) in grain was studied in relation to the other important FHB traits after artificial inoculation with *Fusarium* pathogenes and in relation to important agronomic and physiological traits.

Materials and methods

Field trials. Field experiments were conducted during 2015–2017 at a location in Ruzyně, Prague, Czech Republic. Meteorological data (temperature and rainfall) in March, April, May, June and July were recorded by the meteorological stations of Crop Research Institute (Table 1).

Plant material. Twenty-nine common oat (*Avena sativa* L.) cultivars, differing in agronomic and morphological properties, were used for the study of *Fusarium* resistance (Table 2).

Artificial infection. Oat cultivars were planted in hill plots (Bonnett, Bever, 1947; Ross, Miller, 1955), sowing into 15 cm circles 25 cm apart – 40 seeds per plot, in three replications and two variants (infected and uninfected). The FHB inoculum mixture consisted of isolate samples collected in the Czech Republic (*F. poae* – isolate 22M from Bukovany; *F. graminearum* – isolate 10M2 from Hospříz, isolate 12M1 from Jevíčko and isolate 20M1 from Zdislavice; *F. culmorum* – isolate B from Stupice). Suspensions were applied using a hand-held sprayer in the periods 11–15 June 2015, 15–16 June 2016, and 8–12 June 2017 at full flowering stage of each oat cultivar. Inoculum (conidial suspension 0.8×10^7 ml) was sprayed once onto bunches of 10 flowering panicles selected within hill plots. The inoculated panicles were then kept for 24 h in polythene bags. To minimize year and location effects, it appeared necessary in these conditions to support disease development (when needed) by irrigation of plots (2015 – 1769 litres, 2016 – 1708 litres and 2017 – only 1495 litres due to damage to the water irrigation system).

Evaluation of cultivar resistance. The panicles infected with FHB were visually assessed using a scale of 1–9 (where 1 – no infection, 9 – all spikelets and panicles infected) (Plăcintă et al., 2015). The visual symptom score (VSS) was reliably evaluated in all years only 14 days after the infection. Only in 2015 it was possible to evaluate symptoms in more than one term. In evaluating the cultivars, therefore, VSS detected 14 days after infection were used. Determination of other resistance traits was based on seed samples, which were threshed at a low wind in order not to lose light, infected

Table 1. Average temperatures and sums of rainfall (June and July 2015–2017) at the locality Ruzyně, Prague, Czech Republic

Month	Days	Temperature °C			Rainfall mm		
		2015	2016	2017	2015	2016	2017
June	1–5	19.6	17.8	18.5	0.1	6.7	5.4
	6–10	16.8	18.6	17.0	11.2	0.2	10.7
	11–15	19.6	16.9	19.9	6.4	6.0	0.1
	16–20	13.6	16.9	20.2	3.3	26.4	6.7
	21–25	13.8	22.7	22.1	6.5	9.1	13.9
	26–30	18.7	19.2	18.8	1.3	11.0	61.5
July	1–5	25.5	19.3	18.4	0.1	6.7	3.7
	6–10	20.2	19.9	22.9	9.5	0	2.6
	11–15	19.2	18.8	16.7	3.4	17.2	12.4
	16–20	24.4	19.8	21.6	0.3	3.9	2.1
	21–25	24.4	22.4	20.1	11.8	3.4	7.5
	26–30	17.1	21.4	20.4	5.7	9.2	17.5

Table 2. The main characteristics of the oat cultivars

Cultivar	Country of origin	Kernel covering	Plant height cm	Heading date in June	Thousand grain weight g
Aldan	Russia	naked	97	13.5	23.9
Atego	Czechia	husked	87	9.5	35.5
Avenuda	Czechia	naked	92	11	30.9
Azur	Czechia	husked	92	9	35.4
Bison	Germany	husked	92	8.5	43.3
Cavaliere	Czechia	husked	92	9.5	35.4
Cyril	Czechia	husked	92	8.5	37.7
Dalimil	Czechia	husked	82	8.0	36.2
Florian	Czechia	husked	97	10.0	41.3
Gana	Russia	naked	100	13.5	32.2
Gregor	Czechia	husked	89	9.0	35.6
Izak	Czechia	naked	92	9.5	26.7
Kamil	Czechia	naked	87	12.5	29.1
Kertag	Czechia	husked	92	9.5	39.3
Korok	Czechia	husked	100	9.5	38.2
Neklan	Czechia	husked	82	7.5	39.0
OA 504-6	Canada	naked	104	12.5	27.7
Obelisk	Czechia	husked	92	8.5	39.6
Oberon	Czechia	husked	74	8.5	36.7
Oliver	Czechia	naked	79	11.5	28.4
Otakar	Czechia	naked	95	10.5	27.4
Poseidon	Germany	husked	87	10.5	44.7
Raven	Czechia	husked	92	10.5	36.1
Rozmar	Czechia	husked	97	11.5	36.2
Saul	Czechia	naked	92	12.5	27.9
Seldon	Czechia	husked	97	9.5	40.1
Tibor	Czechia	naked	99	10.5	32.3
Vjatskii	Russia	naked	109	12.5	28.4
Vok	Czechia	husked	92	12.0	37.7

scabby grains. Tolerance to the infection was expressed as percentage reduction from non-inoculated control for the traits thousand grain weight (TGWR) and grain weight per panicle (GWPR). Seeds from infected spikes were analysed for deoxynivalenol (DON) and for T-2 plus HT-2 contents.

Chemical analyses. The contents of DON and T2 plus HT-2 were evaluated by competitive enzyme-linked immunosorbent assay (ELISA) using RIDASCREEN® FAST DON and RIDASCREEN® T-2/HT-2 Toxin kits (R-Biopharm AG, Germany) while following the manufacturer's guidelines. Prior to DON determination, the samples were ground and thoroughly mixed. Next, 2.5 g of each sample was shaken (3 min) with 50 ml of distilled water and filtered. Then 50 µl of the filtrates was used for the ELISA tests. The absorbencies were determined photometrically at 450 nm using a spectrophotometer Sunrise (Tecan, Austria). The software for evaluating enzyme immunoassays *RIDA®SOFT Win. NET* (R-Biopharm AG, Germany) was used for the data processing. DON concentrations were calculated in µg kg^{-1} with limit of quantification 200 µg kg^{-1}. Prior to T-2 plus HT-2 determination, 2.5 g of well homogenized sample was shaken for 10 min with 12.5 ml of ready-to-use extraction buffer and then centrifuged at 3000 g for 10 min at room temperature. The supernatant was diluted 1:2 with methanol:distilled water (70:30, v:v), then further diluted 1:10 with 35% methanol. The amount of 50 µl of the filtrates was used for the ELISA tests. Absorbance at 450 nm was measured using the spectrophotometer Sunrise. Software *RIDA®SOFT Win. NET* was again employed for evaluation of the enzyme immunoassays. T-2 plus HT-2 were calculated in µg kg^{-1}.

Statistical analysis. The data were analysed using the package *UNISTAT*, version 6.5 (Unistat Ltd., UK). Analysis of variance plus Tukey's range test in *Statistica*, version 12 (Statsoft Inc., USA) were used for multiple comparisons. Spearman's correlation coefficients of different combinations of cultivar traits were calculated using package *UNISTAT 6.5*.

Results and discussion

Trait correlations. Response to artificial infection with *Fusarium* pathogens was evaluated in 29 oat cultivars during 2015–2017. Table 3 presents the results of correlation analyses. In these experiments, close relationships in all three years were detected only between traits relating to grain yield reduction (TGWR and GWPR) and between heading date (HD) and TGWR.

Table 3. Spearman's correlation coefficients (*r*) between the examined traits related to Fusarium head blight during three years in oat cultivars

Combination of traits	2015		2016		2017		2015–2017	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
DON *vs* T2 + HT2	**0.20**	**0.0081**	**0.26**	**0.0153**	0.22	0.0587	−0.07	0.3126
DON *vs* VSS	**0.21**	**0.0063**	0.21	0.0528	**0.35**	**0.0022**	**0.41**	**0.0000**
DON *vs* TGWR	**0.558**	**0.0000**	**0.63**	**0.0000**	−0.13	0.2640	**0.36**	**0.0001**
DON *vs* GWPR	**0.22**	**0.0034**	**0.22**	**0.0470**	0.02	0.8502	0.12	0.0528
T2 + HT2 *vs* VSS	0.01	0.9319	0.01	0.9430	−0.05	0.6492	**−0.22**	**0.0007**
T2 + HT2 *vs* TGWR	0.15	0.0509	0.17	0.1128	0.15	0.1996	0.10	0.1044
T2 + HT2 *vs* GWPR	0.02	0.8013	-0.07	0.5433	0.11	0.3697	0.05	0.4303
VSS *vs* TGWR	**0.30**	**0.0000**	**0.28**	**0.0102**	0.16	0.1631	**0.19**	**0.0025**
VSS *vs* GWPR	**0.17**	**0.0291**	0.10	0.3917	0.07	0.5380	**0.13**	**0.0371**
TGWR *vs* GWPR	**0.35**	**0.0000**	**0.29**	**0.0082**	**0.49**	**0.0000**	**0.39**	**0.0000**
HD *vs* DON	**−0.62**	**0.0003**	−0.26	0.1808	−0.16	0.4049	**−0.58**	**0.0009**
HD *vs* T2 + HT2	−0.13	0.5176	−0.23	0.2227	**−0.39**	**0.0381**	**−0.38**	**0.0427**
HD *vs* TGWR	**−0.49**	**0.0074**	**−0.43**	**0.0195**	**−0.41**	**0.0321**	**−0.52**	**0.0041**
PH *vs* DON	−0.3342	0.0764	−0.3122	0.0992	−0.2453	0.2083	**−0.42**	**0.0218**
PH *vs* T2 +HT2	−0.2010	0.2958	−0.2297	0.2306	−0.1921	0.3273	−0.15	0.4445
PH *vs* TGWR	**−0.4124**	**0.0262**	−0.3259	0.0845	−0.1908	0.3308	−0.36	0.0565

Note. VSS – visual symptom score, TGWR – thousand grain weight reduction, GWPR – grain weight per panicle reduction, HD – heading date, PH – plant height; all correlations are significant at $p < 0.05$.

Correlation coefficients between DON and T-2 plus HT-2 contents were significant only in the two test years 2015 and 2016, as were correlation coefficients between DON and TGWR, DON and GWPR, and VSS and TGWR. Correlation coefficients between DON content and VSS were significant in two years of testing (2015 and 2017).

In our study, VSS was reliably evaluated in all years only 14 days after inoculation, and we found it difficult to assess these symptoms in oats in comparison with wheat. This finding is in agreement with other studies on oats resistance (Tekauz et al., 2008; Gagkaeva et al., 2011), because at later developmental stages it becomes difficult to differentiate between natural senescence and FHB symptoms (Tekle et al., 2018). Severe symptoms attributed to *Fusarium* infections in oats are generally rare, and these are mainly observed in Northern Europe (Tekle et al., 2013). Despite the difficulty of evaluation, a statistically significant correlation was found between the VSS and DON traits in two years of testing. On the contrary, no relationship between VSS and T-2 plus HT-2 content was confirmed at all.

Passive resistance mechanisms. Agronomic and physiological traits are not directly involved in disease resistance but provide escape or avoidance of infection and are considered as passive resistance mechanisms (Tekle et al., 2018). Early and naked oat cultivars were found to be less susceptible to FHB (Gavrilova et al., 2008; Parikka et al., 2008). On the other hand, He et al. (2013) found early lines to be more susceptible than late lines. In our study, close negative correlation between heading date and DON content was detected only in 2015, but the negative correlation between heading date and TGWR was significant in all years (Table 3). However, the differences in the heading time between the tested cultivars were not very large.

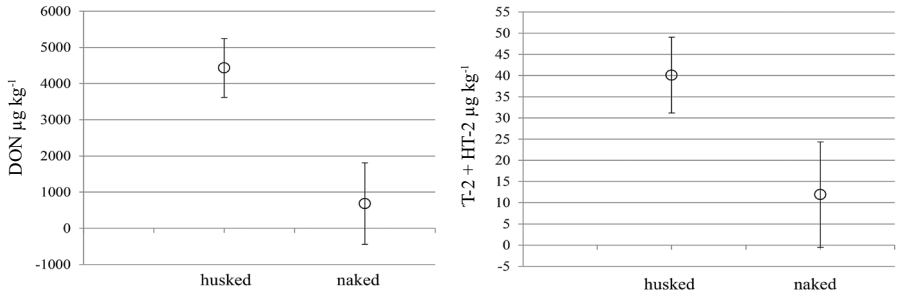
In accordance with Perkowski and Basiński (2008), Gagkaeva et al. (2013), Martin et al. (2018) and Tekle et al. (2018), naked oat cultivars were found to have higher resistance levels for all the tested traits and also lower accumulation of mycotoxins (primarily DON) (Table 4, Fig. 1). Gagkaeva et al. (2017) reported that *Fusarium* fungi can easily infect husks and trichomes and removal of the husk from grains of the cultivated oats resulted in a dramatic (50–55%) reduction in the level of *Fusarium* infection.

During oat processing (dehulling, milling and flaking), some removal of these toxins occurs, but this leads to an increase in toxins in the resulting by-products that are often used as animal fodder (Pettersson et al., 2011). Lower disease incidence and DON content is often associated with taller plants in small grain cereals (He et al., 2013; Tekle et al., 2018). In the present study, we found no significant correlation between plant

Table 4. Mean values (2015–2017) for DON, T-2 plus HT-2 toxins content (µg kg^{-1}), visual symptom score (VSS), reduction of thousand grain weight (TGWR) and reduction of grain weight per panicle (GWPR) in oat cultivars

Cultivar	DON	T-2 + HT-2	VSS (1–9)	TGWR %	GWPR %	Total mean rank
Kamil	824 ab	12.12 ab	1.21	1.25 ab	6.13	5.0
Tibor	556 ab	25.05 ab	1.56	1.17 a	1.31	5.6
Izak	916 ab	9.56 ab	1.63	2.59 abc	7.33	5.8
Otakar	702 ab	10.91 ab	2.06	1.11 a	4.30	6.8
Vjatskii	317 a	24.59 ab	2.00	1.29 ab	10.46	8.6
OA 504-6	441 ab	5.43 a	2.17	4.96 abcde	13.10	9.2
Saul	672 ab	7.67 ab	1.83	6.27 abcdef	17.63	9.4
Avenuda	1119 ab	5.63 a	1.71	6.25 abcdef	18.47	9.6
Gana	393ab	7.39 ab	2.17	3.40 abcd	16.70	10.4
Aldan	527 ab	10.26 ab	2.28	7.19 abcdef	13.83	11.8
Gregor	2316 ab	7.17 a	2.00	14.02 ef	11.1	12.8
Oliver	1289 ab	8.18 ab	2.08	10.80 abcdef	14.18	13.0
Oberon	1862 ab	28.46 ab	2.07	10.08 abcdef	9.57	13.4
Azur	1336 ab	12.70 ab	2.11	12.79 def	11.87	1.5
Korok	2872 ab	44.02 ab	1.94	9.15 abcdef	15.65	16.0
Obelisk	2811 ab	50.64 ab	2.11	8.45 abcdef	11.16	16.6
Seldon	2519 ab	21.08 ab	1.61	15.05 f	17.25	16.6
Bison	2550 ab	26.18 ab	1.94	10.95 bcdef	24.37	17.4
Neklan	3230 ab	23.06 ab	1.94	11.00 bcdef	18.45	17.4
Raven	7137 ab	18.07 ab	2.56	10.45 abcdef	8.35	17.6
Kertag	5998 ab	39.95 ab	1.94	14.86 f	11.31	18.4
Florian	4744 ab	19.29 ab	2.33	10.96 bcdef	14.48	19.0
Vok	1984 ab	118.32 b	2.06	10.38 abcdef	21.44	19.8
Dalimil	7053 ab	45.12 ab	2.39	11.72 cdef	8.31	20.4
Cyril	4044 ab	19.32 ab	2.33	13.17 def	26.18	22.2
Poseidon	6614 ab	40.75 ab	2.33	13.56 def	16.21	23.0
Rozmar	4628 ab	65.41 ab	2.11	12.55 def	24.82	23.6
Atego	9580b	83.47 ab	2.00	14.54 f	19.33	23.8
Cavaliere	8534 ab	58.97 ab	2.61	14.57 f	19.30	26.8
2015	6263 c	22.58 a	1.90	9.47 a	20.15	
2016	2100 b	13.66 a	2.64	9.86 a	7.72	
2017	707 a	59.10 b	1.55	8.73 a	14.88	
Total average	3020	29.27	2.04	9.1	14.22	

Note. * – ANOVA, multiple comparisons by Tukey's range test were used, P = 95%; the means in columns followed by the same letter are not significantly different from each other.



Note. Vertical bars denote 0.95 confidence intervals.

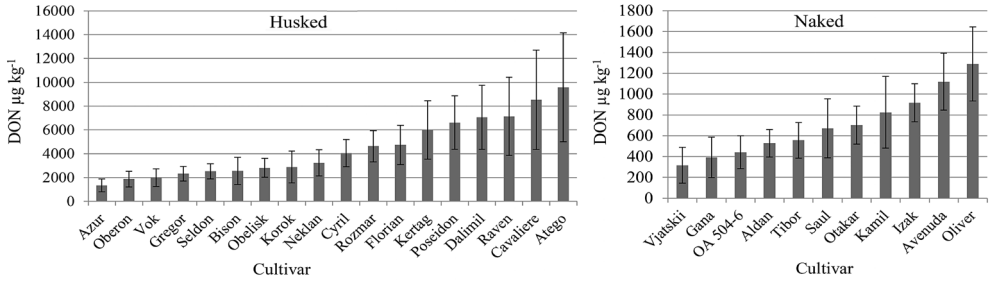
Figure 1. Determination of DON, T-2 plus HT-2 toxins content in oat grains with respect to kernel covering

height and DON content in different years of testing. The possitive correlation between plant height and TGWR was detected only in 2015 (Table 3). The effect of passive resistance mechanisms apparently depends on the genotypes tested and also on inoculum pressure and environmental conditions that determine disease development on plants (Tekle et al., 2018).

Classification of cultivar resistance on the basis of five resistance traits. The panicles infected with FHB were visually assessed, a thousand grain weight and grain weight per panicle were compared between infected and non-infected grains, the contents of DON and T2 plus HT-2 were evaluated by ELISA. The mean DON level among the evaluated cultivars and breeding lines ranged from 317.11 to 9579.56 µg kg^{-1}, and the content of T-2 plus HT-2 toxins ranged from 5.45 to 118.32 µg kg^{-1}. Also, significant differences in TGWR between the tested oat cultivars were determined.

It is clear from Table 4 that most of the oat cultivars tested showed similar resistance levels for all traits, but it was possible also to detect different order in the evaluated traits (e.g., 'Gregor'). Naked oat cultivars 'Kamil', 'Tibor', 'Izak', 'Otakar', 'Vjatskii', OA 504-6, 'Saul', 'Avenuda', 'Gana' and 'Aldan' demonstrated higher resistance against FHB for all the tested traits. The 'Vjatskij', 'Gana' and OA 504-6 showed the lowest DON accumulation among naked oats and also among all the cultivars evaluated (Table 4, Fig. 2). The highest accumulation of DON was found in the 'Atego', which is consistent with other traits. The lowest accumulation of T-2 plus HT-2 toxins was found in the OA 504-6, 'Avenuda' and 'Gregor'. The highest accumulation of T-2 plus HT-2 toxins was determined in the 'Vok'. However, in general, the T-2 plus HT-2 toxins content in oat grain in this experiment was not high. The 'Gregor' showed the best resistance to FHB among the husked oats for all the evaluated traits and also the lowest accumulation of T-2 plus HT-2 toxins. The lowest accumulation of DON among husked oats was found in the cultivar 'Azur' (Fig. 2). Low accumulation of DON appears to be related to the low content of husks in this cultivar.

Disease development under different conditions. Martin et al. (2018) observed that resistance of oat genotypes to toxin contamination was strongly impacted by environmental conditions. In our study, weather condition also affected traits related to resistance. Because plots were irrigated, disease development and mycotoxin accumulation were affected mainly by temperature, and probably in 2017 also by weaker irrigation. Accumulation of DON differed significantly



Note. Vertical bars denote 0.95 confidence intervals.

Figure 2. Deoxynivalenol (DON) content in the cultivars of husked and naked oats

in each year of testing. As shown in Table 4, the highest DON content (6263.2 µg kg^{-1}) was detected in 2015, followed by 2016 (2100.4 µg kg^{-1}), and the lowest DON content (706.5 µg kg^{-1}) was determined in 2017.

In 2015, the temperatures after inoculation in the second half of June were lower than in the next two years (Table 1). Mesterházy et al. (2012) suggests that the application of a mixture of fungal species (isolates) leads to a predominance of one species according to the conditions of the given year. It is possible that the highly pathogenic isolate B of *F. culmorum* (Šíp et al., 2002) could be favoured in these conditions. In 2015, however, there was a significant increase in temperatures in early July. These conditions could significantly promote a higher accumulation of DON. This finding is in agreement with an in situ study by Mylona and Magan (2011), where the optimal temperature for toxin production in oat grains was 25°C.

On the contrary, the highest T-2 plus HT-2 content was detected in 2017. In this year, *F. poae* probably could have been favoured due to higher temperatures and lack of water in the second half of June and, as a result, significantly higher T-2 plus HT-2 content than in other years was found. Investigations by Covarelli et al. (2015) showed that the occurrence of *F. poae* increased when climatic conditions were not favourable for development of such main FHB causal agents as *F. graminearum*. TGWR values did not significantly differ between the years of testing. Detailed analysis of the susceptibility of oats to individual *Fusarium* species is under investigation.

Conclusions

1. In this study, low temperatures during flowering time and after flowering followed by a significant temperature increase in early July were probably the cause of high contamination of oat grains with deoxynivalenol (DON). On the contrary, higher temperatures and less moisture at the time of oat flowering and post-flowering probably contributed to the development of *Fusarium poae* and the subsequent relatively higher accumulation of T-2 plus HT-2 toxins.

2. There were differences in resistance to Fusarium head blight (FHB) between the oat cultivars. Naked oat cultivars were found to have higher resistance levels and also lower accumulation of mycotoxins (primarily DON). Naked oat cultivars 'Kamil', 'Tibor', 'Izak', 'Otakar', 'Vjatskii', OA 504-6, 'Saul', 'Avenuda', 'Gana' and 'Aldan' showed higher levels of resistance against FHB for all the evaluated traits. The lowest concentrations of DON were determined in the 'Vjatskii', 'Gana' and OA 504-6. The 'Gregor' showed the best resistance to FHB among the husked oats for all the evaluated resistance traits, but the lowest concentrations of DON among husked oats were found in the 'Azur' with low content of husks.

Acknowledgements

The authors thank Š. Bártová and D. Pátková, for their technical assistance. This research received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No. 613609 and the Ministry of Agriculture of the Czech Republic (Project No. MZE-RO0418).

Received 27 09 2018
Accepted 03 07 2019

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ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 107, No. 1 (2020), p. 49–54
DOI 10.13080/z-a.2020.107.007

Avižų atsparumas varpų fuzariozei

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Santrauka

2015–2017 m. atlikto tyrimo metu buvo vertintos sėjamosios avižos (*Avena sativa* L.) 29 veislių atsparumas varpų fuzariozei. Avižos buvo pasėtos laukeliuose į 15 cm apskritimus, 25 cm atstumu vienas nuo kito, trimis pakartojimais. Eksperimentą sudarė du variantai: 1) su dirbtiniu užkrėtimu ir 2) be dirbtinio užkrėtimo. Augalai buvo inokuliuoti konidijų suspensija, sudaryta iš *Fusarium poae*, *F. graminearum* ir *F. culmorum* mišinio. Užkrėstumas buvo įvertintas vizualiai matuojant balais 14 dienų po užkrėtimo. Derliaus tolerancija infekcijai buvo išreikšta 1000 grūdų svorio ir grūdų skaičiaus šluotelėje procentiniu sumažėjimu, lyginant su neužkrėstu kontroliniu variantu. Infekuotų šluotelių grūduose buvo tirtas deoksinivalenolio (DON) ir T-2 + HT-2 toksinų kiekis.
Nustatyta, kad siekiant atskleisti avižų atsparumo varpų fuzariozei lygį, būtina nustatyti mikotoksinų kiekį grūduose. Pagal tirtus požymius didesniu atsparumu ir mažesnėmis mikotoksinų koncentracijomis pasižymėjo plikosios avižos veislės. Pagal tirtus požymius varpų fuzariozei buvo atsparesnės veislių 'Kamil', 'Tibor', 'Izak', 'Otakar', 'Vjatskii', OA 504-6, 'Saul', 'Avenuda', 'Gana' ir 'Aldan' plikosios avižos, o mažiausia DON koncentracija buvo nustatyta veislės 'Vjatskii' avižų grūduose. Oro sąlygos turėjo didelę įtaką varpų fuzariozės infekcijos vystymuisi atskirais metais ir su atsparumu susijusiems augalų požymiams.

Reikšminiai žodžiai: atsparumas, *Avena sativa*, *Fusarium* spp., mikotoksinai, veislės.