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HEADING DATE IMPACT ON WHEAT FUSARIUM INFECTION

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SUMMARY

Fusarium head blight (FHB), also called ear blight or scab is economically one of the most serious fungal diseases of wheat in many producing regions of the world. It is a serious threat for the quality of wheat products. Also the production of mycotoxins can be harmful to human and animal health. The aim of this study was to determine the effect of heading date on grain yield due to Fusarium infection that could result in favourable conditions of infection. The earliest heading date had genotype Srpanjka, and the latest Osk.870/08. Grain yield in the treatment with artificial inoculation and fungicide protection varied from 71.9 dt ha^{-1} (Olimpija) to 104.4 dt ha^{-1} (Vulkan), and in the treatment with natural conditions from 74.7 dt ha^{-1} (Divana) to 112.6 dt ha^{-1} (Osk.116/09). The highest AUDPC for the total resistance had genotype Osk.110/09 and the lowest Divana. We conclude that Fusarium infection is dependent on the heading date, depending on weather conditions that could potentially cause strong or weak intensity of infection between heading and flowering days. This research has not found an association between relative grain yield and heading date.

Key words: wheat, *Fusarium*, heading date

INTRODUCTION

Fusarium head blight (FHB) is considered to be one of the most important wheat diseases. Negative effects can be seen in terms of grain yield and quality losses, but also the production of mycotoxins can be harmful to human and animal health. Severe attacks of *Fusarium* species can be expected at higher temperatures (>25˚C) and higher humidity (>70%) at the time of wheat flowering (Bai, 2001), when it is most vulnerable to the attack of this pathogen. The aim of this study was to determine the effect of heading date on grain yield due to Fusarium infection that could result in favourable conditions of infection.

MATERIAL AND METHODS

The experiment was set up in October 2010 at the experimental field of Agricultural Institute Osijek (45°32'N, 18°44'E) at 94 m above sea level, where the soil type is eutric cambisol. Length of the plot was 7 m, and width of 1.08 m, with the sowing rate of 330 kernels/m^2. The experiment was planted as a randomized complete block in three replications of two different treatments (treatment with natural conditions and treatment with Fusarium artificial inoculation and fungicide Prosaro protection). Standard agro-technical measures were made. The method of preparing inocula with *Fusarium culmorum* has been described by Snijders and Van Eeuwijk (1991). Inoculation was performed when 50% of plots were in the flowering phenophase (Zadoks, 1974) in the late afternoon and repeated two days later (19 and 21 May, 2011) due to differences in the time of flowering in different cultivars.

To maintain moisture on the spikes, water was sprayed several times during the day. Symptoms of the disease were recorded at 10, 14, 18 and 22 day after the first inoculation in the treatment where it is carried out artificial infection and usage of fungicide. Values for the entire area within the plot were visually rated using a linear scale from 0 (no infection) to 100 (100% infection), as described in Table 1.

Table 1 Evaluation of infection in the field for the total Fusarium resistance
Tablica 1. Ocjena infekcije u poljskim pokusima za ukupnu Fusarium otpornost

%	
25	4 infected spikelets/1 head *4 inficirana klasića/1 klas*
33	6-7 infected spikelets/1 head *6-7 inficiranih klasića/1 klas*
50	10 infected spikelets /1 head *10 inficiranih klasića/1 klas*
66	12-13 infected spikelets/1 head *12-13 inficiranih klasića/1 klas*
75	15 infected spikelets /1 head *15 inficiranih klasića/1 klas*
95	Almost all spikelets infected *Gotovo svi klasići inficirani*
100	Fully infected *Potpuno inficirano*

The area within a progressive disease of the curve (AUDPC) was calculated (Shaner and Finney, 1977) as an integrated measure of the total intensity of the disease:

$$\text{AUDPC} = \sum_{i=1}^{n} = \{[(Yi + Yi{-}1)/2]*(Xi - Xi{-}1)\}$$

Yi - the percentage of visibly infected spikelets (*Yi*/100) at the ith observation;

Xi - the day of the ith observation, n - total number of observations.

After harvest, grain yield was measured in both treatments. Statistical analysis were done by using SAS/STAT.

RESULTS AND DISCUSSION

Analysis of variance revealed statistically significant differences between genotypes, treatments and genotype by treatment interaction for grain yield and AUDPC for total FHB resistance (Table 2). The earliest heading date had genotype Srpanjka, and the latest Osk.870/08. In the treatment with artificial inoculation and fungicide protection grain yield varied from 71.9 dt ha^{-1} (Olimpija) to 104.4 dt ha^{-1} (Vulkan), and in treatment with natural conditions (control) from 74.7 dt ha^{-1} (Divana) to 112.6 dt ha^{-1} (Osk.116/09) The highest AUDPC for the total resistance had genotype Osk.110/09 (236.7) and the lowest Divana (12.5) (Table 3).

Table 2 Analysis of variance for grain yield and AUDPC for total FHB resistance
Tablica 2. Analiza varijance za urod zrna i AUDPC za ukupnu FHB otpornost

Source of variation/ *Izvor varijacije*	DF/*SS*	F-value/*F-vrijednost*	
		Grain yield/*Urod zrna*	AUDPC for total FHB resistance/*AUDPC za ukupnu FHB otpornost*
Genotype/*Genotip* (G)	23	5.83***	7.38***
Replication/*Repeticija* (R)	2	16.30***	6.88**
Treatment/*Tretman* (T)	1	21.36***	274.82***
G*T	23	1.25ns	7.38***
Error/*Pogreška*	94		

Table 3 Heading date, the mean values of grain yield in treatment with protection and inoculation (F+I) and in control, AUDPC for total FHB resistance in treatment with fungicide protection and inoculation (AFTFR), relative grain yield loss (RGYL)

Tablica 3. Datum klasanja, srednje vrijednosti uroda zrna u tretmanu gdje je korištena zaštita i umjetna infekcija (F+I), te u kontrolnom tretmanu, AUDPC za ukupnu FHB otpornost u tretmanu gdje je korištena zaštita i umjetna infekcija (F+I), i relativni gubitak uroda zrna (RGUZ)

Genotype/*Genotip*	Heading date/*Datum klasanja*	Grain yield/*Urod zrna* (F+I) (dt ha^{-1})	Audpc for total FHB resistance/ *AUDPC za ukupnu FHB otpornost* (F+I)	Grain yield/Urod zrna (control/ *kontrola*) (dt ha^{-1})	RGYL between treatments/ *RGUZ između tretmana* (%)
Srpanjka	6 May 2011	90.6	41.5	92.3	1.8
Lucija	6 May 2011	94.2	25.5	103.5	9.0
Zlata	8 May 2011	93.4	35.5	92.0	-1.5
Felix	8 May 2011	93.4	14.5	93.2	-0.2
Renata	9 May 2011	90.4	35.5	95.9	5.7
Seka	10 May 2011	89.0	51.5	97.5	8.7
Sana	11 May 2011	79.0	140.0	103.4	23.6
Alka	11 May 2011	96.0	40.5	101.4	5.3
Aida	11 May 2011	93.4	110.0	96.8	3.5
Katarina	11 May 2011	84.6	72.2	93.6	9.6
Olimpija	11 May 2011	71.9	20.0	84.9	15.3
Vulkan	11 May 2011	104.4	28.3	98.1	-6.4
Zitarka	12 May 2011	82.6	55.2	84.8	2.6
Nadalina	12 May 2011	87.3	47.8	88.7	1.6
Kraljica	12 May 2011	99.6	35.5	98.8	-0.8
Osk.151/09	12 May 2011	93.4	93.5	108.0	13.5
Divana	13 May 2011	76.4	12.5	74.7	-2.3
Jana	13 May 2011	102.5	41.5	104.3	1.7
Nova Zitarka	13 May 2011	83.2	157.7	88.5	6.0
Silvija	13 May 2011	87.8	70.5	92.0	4.6
Osk.110/09	13 May 2011	77.8	236.7	87.2	10.8
Osk.116/09	13 May 2011	97.4	56.2	112.6	13.5
Soissons	14 May 2011	87.9	47.3	89.9	2.2
Osk.870/08	15 May 2011	87.5	99.3	103.9	15.8
Average/*Prosjek*		89.3	65.4	95.2	6.2

In average a higher grain yield was achieved in the control treatment with natural conditions (95.2 dt ha^{-1}) than in the treatment with Fusarium artificial inoculation and fungicide protection (89.3 dt ha^{-1}), where it can be concluded that the infectious pressure in favorable infection conditions can override the protective effects of fungicides. The highest differences between these two treatments (relative grain yield loss) had genotype Sana (23.6%). In this study, all genotypes were treated at the same time, to determine how increased infectious pressure at a given time can affect the resistance genotypes, and hence the losses in grain yield. Statistically significant correlations were achieved between the AUDPC for total FHB resistance and heading date and between the AUDPC for total FHB resistance and relative grain yield loss between the two treatments, and not any between heading date and relative grain yield loss between the two treatments (Table 4).

Table 4 Correlation analysis between the heading date and AUDPC for total FHB resistance in the treatment with artificial infection and fungicide protection, and relative grain yield loss obtained by the ratio of fungicide treatments and artificial infection compared to control, and the same relative yield loss with AUDPC for total FHB resistance

Tablica 4. Korelacijske analize između datuma klasanja i AUDPC-a za ukupnu FHB otpornost u tretmanu sa umjetnom infekcijom i zaštitom fungicidom, te relativni gubitak uroda zrna dobiven omjerom tretmana sa zaštitom i inokulacijom, u usporedbi sa kontrolnim tretmanom, te relativnog gubitka uroda zrna sa AUDPC-om za ukupnu FHB otpornost

Trait/*Svojstvo*	AUDPC	RGYL from F+I/C/*RGUZ iz F+I/C*
Heading date/*Datum klasanja*	0.43**	0.13ns
RGYL from F+I/C / *RGUZ iz F+I/C*	0.56**	

Many authors suggest that earlier genotypes had higher Fusarium resistance. Gervais et al. (2003) identified the co-localization of the QTL's for resistance and flowering date at chromosome 2B. FHB resistance was significantly correlated with flowering date (Klahr et al., 2007). Schmolke et al. (2008) found QTL's for resistance at chromosome 7BS which are related to the QTL for flowering date, but they believe that the additive effect on the flowering date had small importance. Emrich et al. (2008) have determined that the heading date was negatively correlated with intensity of infection. In this study, the statistically significant correlation was between the heading date and AUDPC for the total resistance. This research has not found an association between relative grain yield and heading date.

CONCLUSION

Based on our studies we conclude that Fusarium infection is dependent on the heading date, depending on weather conditions that could potentially cause strong or weak intensity of infection between heading and flowering days. Best time for protection against this disease is at the time of flowering.

SAŽETAK

UTJECAJ DATUMA KLASANJA NA INFEKCIJU PŠENICA FUSARIUMOM

Fusarijska palež klasa (FHB), još nazvana palež klasa ili scab, u gospodarskom smislu je jedna od najozbiljnijih gljivičnih bolesti pšenice u mnogim proizvodnim regijama svijeta. Može stvoriti ozbiljnu prijetnju za kvalitetu pšeničnih proizvoda. Proizvodi i mikotoksine koji mogu biti štetni za zdravlje ljudi i životinja. Cilj ovog istraživanja bio je utvrditi utjecaj datuma klasanja na urod zrna uslijed Fusarium infekcije do koje bi moglo doći u povoljnijim vremenskim uvjetima za zarazu. Najraniji datum klasanja imao je genotip Srpanjka, a najkasniji Osk.870/08. Urod zrna u tretmanu s umjetnom infekcijom i zaštitom fungicidom bio je od 71,9 dt ha^{-1} (Olimpija) do 104,4 dt ha^{-1} (Vulkan), a u tretmanu s prirodnim uvjetima od 74,7 dt ha^{-1} (Divana) do 112,6 dt ha^{-1} (Osk.116/09). Najveći AUDPC za ukupnu otpornost imao je genotip Osk.110/09, a najmanji Divana. Možemo zaključiti da Fusarium infekcija ovisi o datumu klasanja, ovisno o vremenskim uvjetima koji bi mogli izazvati jači ili slabiji intenzitet zaraze između datuma klasanja i cvjetanja. Ovim istraživanjem nije pronađena veza između relativnog uroda zrna i datuma klasanja.

Ključne riječi: pšenica, *Fusarium*, datum klasanja

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