

DOI: 10.2478/v10129-011-0026-x

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THE INFLUENCE OF *FUSARIUM* EAR INFECTION ON THE MAIZE YIELD
AND MYCOTOXIN CONTENT (TRANSYLVANIA-ROMANIA)

ABSTRACT

Maize is the host for a large number of pathogens, which invade all of its organs from the germination until being harvest, ear and grain infection often persistent even during storage. Diseases, through their symptoms reduce significantly the quantity and the quality of yield, estimated between 7-17% but, in the favorable years for this disease, they can be much greater. *Fusarium* diseases reduce yield value and quality by massive accumulation of *Fusarium* mycelium biomass (about 85%) on grain and ears and by mycotoxin contamination such as deoxynivalenol (DON), zearalenone (ZEA) and fumonisins (FUM). In this paper are presented aspects regarding the reaction of some maize hybrids under *Fusarium* spp. natural and artificial infections; the effect of *Fusarium* ear infection on yield, grain chemical composition, and mycotoxin content; the correlation between ear rot disease degree and yield ability, starch, protein and fat content. ANOVA evidenced the significant influence of experimental factors: infection conditions with *Fusarium* spp., maize genotypes, and their interaction on expression of the disease degree, yield capacity, protein, starch, fat and DON content. Average yield losses ranged between 7,0-9,3% during the experimental period. The hybrids Turda Star and Turda Favorit were more resistant to *Fusarium* ear rot, and Turda 165 was the most susceptible one. The artificial infection of ear with *Fusarium* spp. determined significantly decrease of starch and fat content and increases the protein and DON content for the most part of maize hybrids. Between rot diseased kernels and DON content a positive correlation was determined.

Key words: maize ear rot, *Fusarium* infection, mycotoxin content

INTRODUCTION

Maize is the host for a large number of pathogens, which invade all of its organs from the germination until the harvest, ear and grain infection often remain even during the storage. Diseases, through their symptoms reduce significantly the quantity and the quality of the yield, estimated between 7-17% but, in the favorable years for the diseases, they can be much greater. (Muresan *et al.*,1973; Moose,2004; Nagy *et al.*,2006). Fuzarienne diseases reduce yield value and quality by massive accumulation by mycelium biomass of *Fusarium* (about 85%) on the grain and ears and by mycotoxin contamination such as deoxynivalenol (DON) zearalenone (ZEA) and fumonisins. (FUM).(Vyn and Tollenar,1998; Yazar and Omurtag, 2008; Czembor *et al.*, 2009).

In the paper are presented aspects regarding the reaction of some maize hybrids under *Fusarium spp.* natural and artificial infections; the effect of *Fusarium* ear infection on the yield, grain chemical composition, and mycotoxin content; the correlation between ear rot diseased degree and yield ability and starch, protein,fat and DON content.

MATERIAL AND METHODS

The experiments were carried out at ARDS- Turda during three years. For realizing of target of paper it was organized of byfactorial experiment by type $A \times B \times n$, after block split in three replications. Factor A= Infections conditions with *Fusarium spp.*: natural and artificial. Factor B=Hybrids: Turda 145, Turda 165, Turda Mold 188, Turda 200, Turda 201, Turda Star and Turda Favorit. Plant population density was by 70000 plants/ha. It was analyzed next traits: ear rot expressed by diseased grains (%) before harvesting; yield capacity expressed in kg/ha with 85 % dry matter and content of protein, starch, oil, fibers and DON. For determined DON content high pressure liquid chromatography (HPLC) was used. Statistical methods ANOVA, correlation and regression were used.

RESULTS AND DISCUSSION

The evolution of temperature and rainfall from three experimental years, from maize vegetation period have influenced considerable *Fusarium* ear rot, assured a good discriminations of tested genotypes.(Table1).

ANOVA ear rot and yield in years x infection conditions x hybrids experiment evidenced the significant influence for almost experimental factors: *Fusarium* infection, hybrids and their interactions. Ear length (cm) is influenced significantly by such factors as years, infection conditions and *years* \times *hybrids*, respectively ear diameter (cm) by years and infection conditions. Polyfactorial interaction is significant only for yield capacity of maize hybrids (Table2).

Climatic elements in vegetative period of maize crop in Turda, 2005-2007

Table 1

Year	Deviation from normal (\pm)						April-September
	April	May	June	July	August	Sept.	
Temperature (\pm° C)							
2005	0.1	1.0	-0.5	0.3	0.1	1.3	2.3
2006	1.1	-0.4	-0.1	1.8	-0.9	0.9	2.4
2007	1.1	2.3	2.6	2.5	0.7	-1.2	8.0
Normal (49 years)	9.7	14.7	17.7	19.4	18.9	14.8	15.9
Rainfall (total mm)							
2005	35.5	-14.5	-14.5	60.5	128.5	23.3	218.8
2006	24.8	-8.5	37.3	-54.6	96.3	-6.5	50.5
2007	34.4	-3.8	-20.3	-20.3	61.1	44.7	95.8
Normal (49 years)	46.0	69.4	80.9	71.1	52.3	39.1	358.8

ANOVA for ear rot and yield in experiment years \times infection conditions \times hybrids (Turda, 2005-2007)

Table 2

Source of variation	FD	S^2			
		Diseased grains [arcsin $\sqrt{\%$]	Ear length [cm]	Ear diameter [cm]	Yield [kg/ha]
Total	125				
Replicated	2				
A. Years	2	26.5	154.6***	7.05***	273885472.0***
Error (a)	4	8.1	0.9	0.20	574990.7
B. Infection conditions	1	6384.5***	36.8**	0.47*	22200366.0***
A \times B	2	545.7***	2.4	0.06	1656561.5***
Error (b)	6	5.3	2.2	0.07	108643.1
C. Hybrids	6	39.2***	20.2***	0.08	4227284.5***
A \times C	12	14.4*	4.8*	0.05	1349293.6***
B \times C	6	16.9*	2.4	0.04	182731.5*
A \times B \times C	12	6.8	1.2	0.02	275279.4***
Error (c)	72	6.2	1.7	0.04	109803.2

Table 3
The influence of infection conditions with *Fusarium spp.* on the ear rot, at some maize hybrids (Turda, 2005-2007)

No.	Factors	Ear rot										
		Diseased grains					Ear length			Ear diameter		
		%	arcsin√%	rel.	d	s	cm	d	s	cm	d	s
A. Years												
1.	2005	6.0	14.2	100.0	0.0	Mt.	19.3	0.0	Mt.	4.8	0.0	Mt.
2.	2006	5.8	13.9	97.8	-0.3	-	15.5	-3.8	000	4.0	-0.8	00
3.	2007	7.1	15.4	108.4	1.2	-	17.5	-1.8	000	4.6	-0.2	-
	LSD 5%				1.7			0.6			0.3	
	LSD 1%				2.9			0.9			0.4	
	LSD 0.1 %				5.4			1.6			0.8	
B. Infection conditions												
1	Natural	1.7	7.4	100.0	0.0	Mt.	18.0	0.0	Mt.	4.6	0.0	Mt.
2	Artificial	13.6	21.6	293.8	14.2	***	16.9	-1.1	00	4.4	-0.2	0
	LSD 5%				1.0			0.6			0.1	
	LSD 1%				1.5			1.0			0.2	
	LSD 0.1 %				2.5			1.5			0.3	
C. Hybrids												
1	Turda 145	5.8	13.9	100.0	0.0	Mt.	16.8	0.0	Mt.	4.4	0.0	Mt.
2	Turda 165	8.8	17.3	123.9	3.3	***	17.0	0.2	-	4.5	0.1	-
3	Turda Mold 188	6.1	14.3	102.6	0.4	-	16.5	-0.3	-	4.5	0.1	-
4	Turda 200	6.1	14.3	102.6	0.4	-	16.8	0.0	-	4.6	0.2	-
5	Turda 201	7.1	15.4	110.6	1.5	-	17.0	0.2	-	4.5	0.0	-
6	Turda Star	5.0	12.9	92.5	-1.0	-	18.9	2.1	***	4.5	0.0	-
7	Turda Favorit	5.2	13.2	94.9	-0.7	-	19.0	2.2	***	4.4	-0.1	-
	LSD 5%				1.7			0.9			0.1	
	LSD 1%				2.2			1.2			0.2	
	LSD 0.1 %				2.9			1.5			0.3	

From three experimental years, 2007 was more favorable for *Fusarium* ear rot, diseased kernels percentage being by 7.1%. Artificial infection condition were determined an attack degree higher by 13.6%, comparative natural infection only by 1,7%. Ear length and diameter significantly were reduced. Analyzing hybrids behavior only Turda 165 prove to be more susceptible to *Fusarium* ear rot. (Table3).

Yield obtained in these experimental years, had the values between 6127.3-10627.7 kg/ha, 2005 being the most favorable. Artificial infections were determined

a very significant decrease of yield, in average with 839.5 kg/ha in absolute value, respectively with 10.4 % in relative value. Turda 200 and Turda 201 prove to be less productive than check Turda 145 hybrid. Turda Favorit and Turda Star, performed hybrids realized a yield by 7902.4 kg/ha respectively 8601.6 kg/ha, these being genetic inheritance with a higher yield capacity. (Table4).

Table 4
The influence of infection conditions with *Fusarium spp.* on the yield, at some maize hybrids (Turda, 2005-2007)

No.	Factors	Yield			
		[kg/ha]	rel.	d	s
A. Years					
1.	2005	10627.7	100.0	0.0	Mt
2.	2006	6127.3	57.7	-4500.4	000
3.	2007	6286.3	59.2	-4341.4	000
		LSD 5%		460.0	
		LSD 1%		761.2	
		LSD 0.1 %		1424.7	
B. Infection conditions					
1.	Natural	8100.2	100.0	0.0	Mt.
2.	Artificial	7260.7	89.6	-839.5	000
		LSD 5%		143.8	
		DSD 1%		217.9	
		DSD 0.1 %		350.0	
C. Hybrids					
1.	Turda 145	7635.2	100.0	0.0	Mt.
2.	Turda 165	7702.9	100.9	67.7	-
3.	Turda Mold 188	7494.7	98.2	-140.6	-
4.	Turda 200	7076.6	92.7	-558.7	000
5.	Turda 201	7349.7	96.3	-285.6	0
6.	Turda Star	8601.6	112.7	966.4	***
7.	Turda Favorit	7902.4	103.5	267.2	*
		LSD 5%		219.8	
		DSD 1%		292.5	
		DSD 0.1 %		378.4	

The interaction of infection conditions, kernels diseased and yield is showed that the amplitude of ear rot was between 0.9-2.2% in natural conditions and 10,8-19,3% in artificial conditions. Turda 165 and Turda 201 hybrids were presented the highest attack intensities, rich up to 19.3% kernels diseased. In natural conditions, the yield varying between 7453-8904 kg/ha and between 6700-8300 kg/ha in *Fusarium* artifi-

cial inoculations. Yield losses varying between 7-15% in relative values, depend on hybrid, respectively between 604-1227 kg/ha in absolute value, statistic assured. (Table5).

Table 5

The effect of infection conditions with *Fusarium spp.* on the ear diseased degree and on the yield (Turda, 2005-2007)

No	Hybrids	Infection conditions	Diseased grains					Yield			
			%	arcsin√%	rel.	d	s	[kg/ha]	rel	d	s
1	Turda 145	natural	1.7	7.5	100.0	0.0	Mt.	8249	100	0.0	mt.
		artificial	12.2	20.4	272	12.9	***	7022	85	-1227	000
2	Turda 165	natural	2.2	8.5	100.0	0.0	Mt.	8114	100	0.0	mt.
		artificial	19.3	26.0	305	17.5	***	7292	90	-822	000
3	Turda Mold 188	naturall	2.0	8.2	100.0	0.0	Mt.	7923	100	0.0	mt.
		artificia	12.2	20.3	246	12.1	***	7067	89	-856	000
4	Turda 200	natural	1.4	6.7	100.0	0.0	Mt.	7453	100	0.0	mt.
		artificial	13.8	21.8	325	15.1	***	6700	90	-753	000
5	Turda 201	natural	2.1	8.4	100.0	0.0	Mt.	7812	100	0.0	Mt
		artificial	14.4	22.3	265	13.9	***	6887	88	-925	000
6	Turda Star	natural	1.3	6.6	100.0	0.0	Mt.	8904	100	0.0	mt.
		artificial	10.8	19.2	291	12.6	***	8300	93	-604	000
7	Turda Favorit	natural	0.9	5.4	100.0	0.0	Mt.	8247	100	0.0	mt.
		artificial	12.9	21.0	388	15.6	***	7558	92	-690	000
Average		natural	1.7	7.3	100.0	0.0	Mt.	8100	100	0.0	mt.
		artificial	13.6	21.6	294	14.2	***	7261	90	-839	000
							LSD 5%		2.4		321
							LSD 1%		3.2		437
							LSD 0.1%		4.4		591

The effect of *Fusarium* infection conditions on the chemical composition of maize grain was studied. Starch content was diminished significantly for almost hybrids and protein content systematic was higher.(Fig.1).

Deoxynivalenol content (DON) for 7 maize hybrids was between 5,77-14,25 ppm in natural conditions and between 15,21-32,80 ppm in artificial infections. Determined DON levels depart with much more admitted limits by EU legislation, which are above 5-10 ppm in function different factors. (Fig.2).

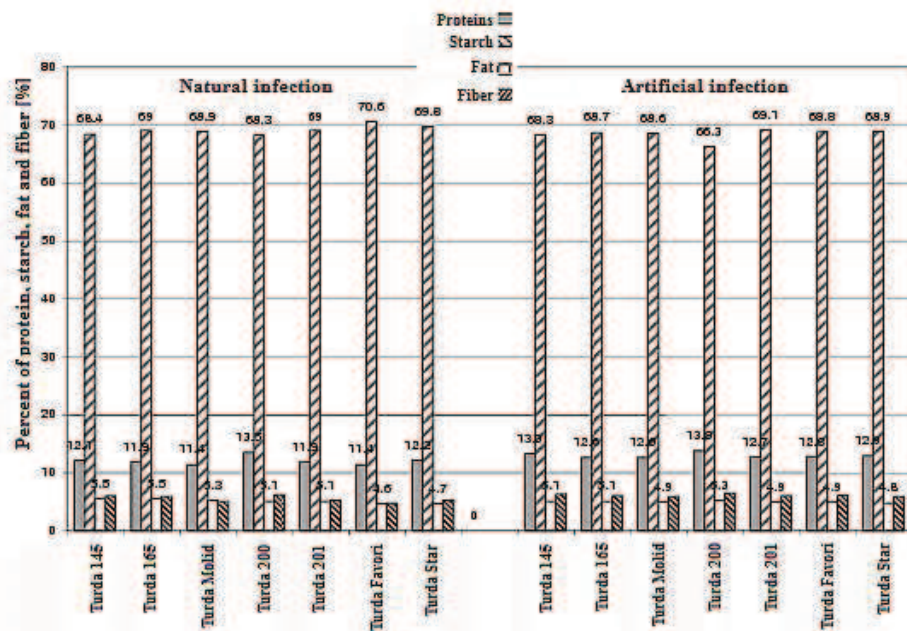


Fig.1. The influence of *Fusarium* spp. infection conditions on the grain quality of maize grain

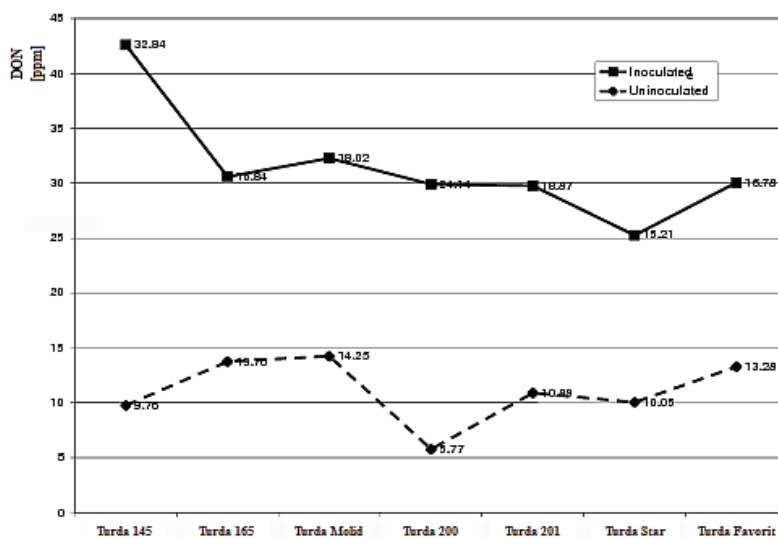


Fig.2. The influence of *Fusarium* spp. infection conditions on the DON content at 7 maize hybrids

The highest differences, in DON content between natural and artificial infections, for Turda 145 and Turda 200 hybrids were registered. (Fig.3).

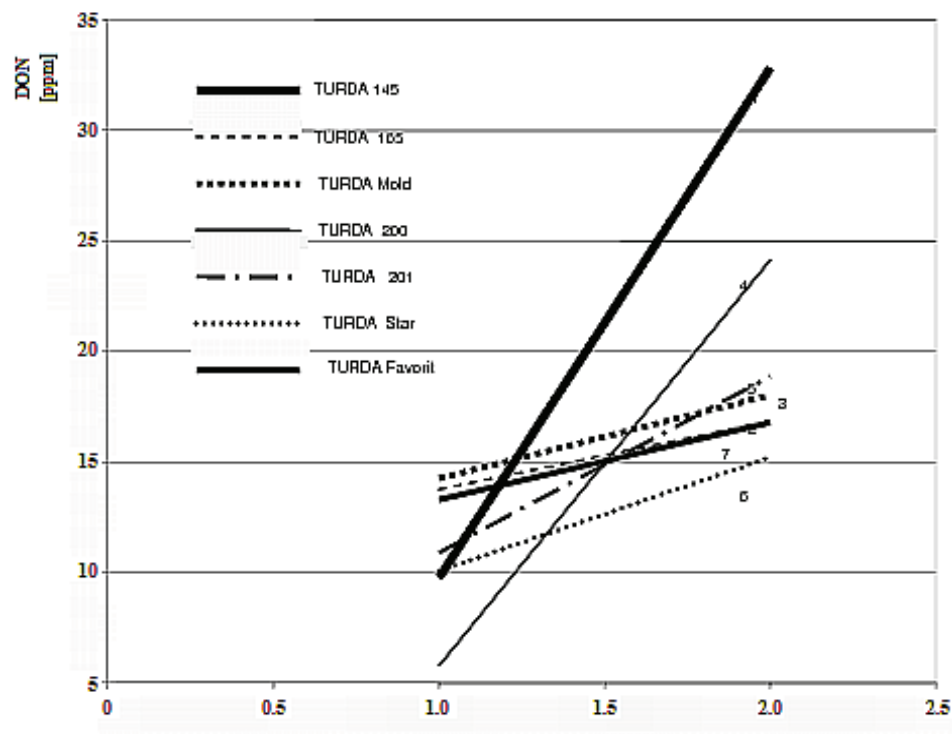


Fig.3. Effect of Fusarium spp. ear infections on the DON content, in 7 maize hybrids

The relationship between diseased kernels and DON content is defined by regression equation:

$$y = 0.3537 + 8.0038x, R^2 = 0.5617^*$$

The increase with one unity of ear rot attack degree determined an increase DON level with 8.0038 ppm. (Fig.4).

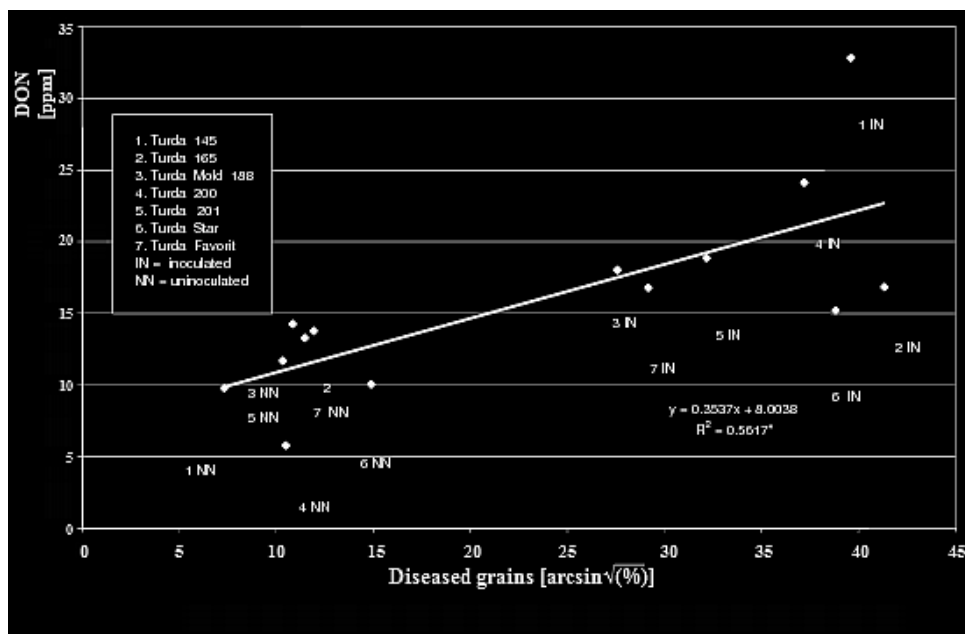


Fig.4. Relationship between diseased grains and DON content in 7 maize hybrids

CONCLUSIONS

1. Ear rot diseased degree with *Fusarium* spp. affected significant yield capacity, chemical compositions and DON content of maize hybrids which have tested.
2. Average yield losses of tested hybrids, in three years, were varying between 7,0 and 15,0 %.
3. Under artificial infection conditions with *Fusarium* spp. was registered a significant diminishing of starch and fat content, almost all maize hybrids which are tested, whereas, protein content increased comparatively with uninoculated variants.
4. Deoxynivalenol (DON) content substantially increased in *Fusarium* spp. artificial infections for all maize genotypes tested, rich up to 32,84 ppm.
5. The relationship between diseased grains and DON is positive and significant, increasing of *Fusarium* spp. ear rot attack degree, determined a large quantity of DON mycotoxin.

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