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RESULTS REGARDING THE FUSARIUM HEAD BLIGHT ATTACK ON WHEAT IN WESTERN ROMANIA

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Abstract

This paper presents some results regarding the attack of the Fusarium head blight (FHB) in the year 2019 at Oradea, Romania. The climatically conditions (a great number of days with rainfall and high relative humidity) favoured a strong attack, the most wheat genotypes being strongly damaged... Our new cultivars Dacic and Lovrin 5 X had a good reaction to the disease, their yields being significant upper to experimental average.

About the effects of attack on ears, the genotypes: Otilia, Ursita, F.14078 GP1 and Dacic were the list affected by Fusarium. The effect of Fusarium attack were strong in reducing the thousand kernel weight (TKW) and finally in yield decrease.

These unusual climatically conditions were a good opportunity for breeding, selection of genotypes to FHB resistance being the most important target on this year.

Key words: cultivar, wheat, yield, resistance, fusarium.

INTRODUCTION

A challenge for this century is to increase production of cultivars resistant to biotic (like wheat scab) and non-biotic stress, without increasing the land area production (Tessman and Sanford, 2019).

There are more than 50 species and varieties of *Fusarium* sp. which attacks a lot of cultivated plants (Ittu et al., 1979). The most grave symptoms in wheat are caused (in order) by *Fusarium graminearum* Schwalbe f. c. *Giberella zeae* (Schw) Petch, *Fusarium avenaceum, Fusarium culmorum* and *Fusarium nivale*. *Durum* wheat is more susceptible to *Fusarium* than bread wheat (Buerstmayr et al., 2019).

In warm and humid conditions, *Fusarium graminearum* is the pathogen that caused the disease, but in cooler and humid environments, *Fusarium culmorum* and *Fusarium avenaceum* ones are frequent (Tessman and Sanford, 2019). *Fusarium* head blight (FHB) occurs especially in areas with warm and humid summer (Mesterhazy, 2001). Climatically factors that favoured infection are: temperature (17-21^{0}C) during the flowering period, 7-12 hours of sunlight brightness daily and high (70-80%) relative humidity (Bunta, 1992). Temperature and humidity around anthesis influence FHB infection and disease development, resistance to disease may not be genetically controlled (Buerstmayr et al., 2019).

A fungicide control is expensive and not always effective enough, also breeding of resistant cultivars seems to be the most important task (Mesterhazy, 2001). Under epidemic conditions, even the most efficient fungicides may not be good enough to keep the toxin level below the critical threshold, particularly on susceptible cultivars (Mesterhazy et al., 2011).

Infected grains contain toxic fungal metabolites (mycotoxins), like deoxynivalenol (DON), that make it unsuitable for food and feed (Zhu et al., 2019). Fusarium head blight (FHB) significantly reduces the percentage of high-molecular- weight glutenins and low-molecular-weight glutenins, two important components of gluten (Tessmann, 2019).

Disease infection occurs during or just after anthesis, when open florets provide the opportunity for the pathogen to enter and initiate infection (Tessmann, 2019). Morphological traits of wheat can act as barrier between pathogen and plant and provide a passive form of resistance to disease. Plant height, flowering time, anther extrusion, spike density, spikelet number are some of the traits described related to FHB.

Genotypes witch have higher plant height have better resistance to FHB (Spanic et al., 2011). Plant height was negatively correlated with all disease traits (Tessmann and Sanford, 2019). In addition, spike inclination was negatively correlated with all disease traits, indicating that more inclined spikes had lower disease levels.

Heading date can impact FHB, since in early or late hearing date can provide escape from infection (Petersen et al., 2016). Between hearing date and *Fusarium* damaged kernels and DON were identified positive significant correlations, early genotypes being more resistant to FHB.

Negative correlations between morphological and scab traits were observed across all traits. Despite their small effects, traits as spike length, spikelet number and spike inclination can function as passive resistance mechanisms, reducing pathogen contact with the floral tissue (Tessmann and Sanford, 2019).

Buerstmayr et al. (2019) considered that there are two types of FHB resistance in wheat: type I, resistance to initial infection and type II, the resistance to the spread to infection within a plant. These two types vary independently among cultivars.

The plant defence to FHB can be active resistance (genetically factors) or passive one (morphological and developmental traits: plant height, anther extrusion, and flowering date).

The resistance to FHB is race non-specific and gives protection against several *Fusarium* species (Mesterhazy, 2001), the resistance being a complex phenomenon. A central importance to FHB is (Buerstmayr et al., 2019):

1. The abundance and aggressiveness of inoculums around anthesis;

2. The environmental conditions during the critical period;
3. The susceptibility or resistance status of the plant;

Multiple mechanisms of host resistance to FHB can be evaluated:

1. Initial infection
2. Spread of pathogen in spike tissues
3. Deoxynivalenol (DON) accumulation
4. Kernel infection
5. Yield reduction (Xu et al., 2020).

Resistance to type 1 is associated with phenological, morphological and flower biology traits, such as: plant height, days to hearing, anther extrusion. Cleistogamy is the best type 1 resistance against FHB. Closed-flowering or rapid anther extrusion genotypes are more resistant to FHB than the genotypes where the anther was partially extruded (Tassmann, 2019).

The breeding for FHB is difficult (Bunta Gh. and Bunta A., 1992) because:

1. There are a lot of *Fusarium* species, very adaptable;
2. Don't exists a precise method for resistance evaluation;
3. The same genotypes have different reactions in different areas, years and inoculums;
4. Don't be available sources of immunity to disease.

Resistant cultivars are one of the must important ways to control or reduce the effects of FHB. That is a quantitative disease, involving multiple genes with major and minor effects (Tessmann, 2019). In Europe, some cultivars are sources of resistance: Arina, Fundulea 201 R, Renan, and Remus.

Different authors identified during the years some sources for resistance to FHB: Sumai 3, a Chinese spring variety and Frontana, from Brazil (Zhu et al., 2019). *Triticum dicoccoides* and different local germplasm could be additional sources of resistance. Frontana ensure resistance to initial infection while Sumai 3 to fungal spread within a spike. Ittu Mariana and collaborators (1989) presents some cultivars with good resistance to FHB: Wu Gong, Mai, Na Su 2 (China), Nobeoka Bozu (Japan), Libelulla (Italy), Bizel (France).

Sumai 3, Ning 7840, Yangmai 158, Ningmai 9 and other *Fusarium* resistant cultivar were developed through standard methods (Ma et al., 2019). In addition to inter-varietals crosses, other methods were used: substitution and translocation lines with alien chromosomes or chromosomes fragments, somaclonal variation, recurrent selection, molecular marker-assisted selection. Recently, *Fhb1* has been cloned and diagnostic markers have been developed, which will facilitate successful deployment of *Fhb 1* in wheat breeding (Bai et al., 2018).

One breeding methods to increase resistance to FHB is selection of seedling inoculated with different races of *Fusarium* (Shin et al., 2014), a simple, rapid and reliable for the early screening of resistance.

In Romania, some old cultivars were identified to be resistant: Turda 195, Alina, Silvana Fundulea 29 ((Moldovan, et al., 1986). In the heredity of resistance to *Fusarium* there are more types of genetic actions, the non-additive ones (dominances and epitasis) being predominates (Moldovan and col., 1988).

In north-west Romania (Crisana county), strong head blight attacks were recorded in the years: 1970, 1985, 1991 (Bunta, 1992).

MATERIAL AND METHOD

The experiment vas conducted in the experimental field of the Agricultural Research and Development Station Lovrin, situated near the town Oradea, in the North-west of Romania. It consists in 25 genotypes (cultivars and breeding lines) tested during the agricultural year 2018-2019. The surfaces of plots were 5 square meters and the number of replicates was three, randomized. The results were computed statistically and the interpretation of dates was done by limit standard deviation (LSD). The correlation between characters was used too. The best trend line model of interactions between characters (linear, exponential, power, polynomial and mowing line) were computed and than the most significant were presented in the figures.

The yield results of genotypes were compared with the average of experiment. In the list of cultivars is included the Russian old cultivar Bezostaya 1, to facilitate the observation of genetically progress during the last period.

For a better understanding of genotypes reaction to FHB, in the paper are presented the climatically parameters (temperature, precipitations and humidity) registered during the months May and June.

RESULTS AND DISCUSSION

Because it is known that the apparition and spread of inoculums of Fusarium is very dependent to climatically conditions, in table 1 are presented the daily averaged temperature, sum of daily precipitations and the humidity of atmosphere, during the months May and June. It can see that a number of 22 days in May and 12 days in June were raining, generating high humidity, at temperatures between 14.8ºC and 23.0ºC. The sum of precipitations exceeded 100.0 mm/m^2 in the both months, more than multi-annual averages. In consequence, the genotypes were affected by disease, indifferent of their precocity.

Table 1

Climatically factors between heading date and maturity of wheat.
Oradea, 2019

Date	May			June		
	Temperature (ºC)	Precipitations (mm)	Humidity (%)	Temperature (ºC)	Precipitations (mm)	Humidity (%)
1	13.1	8.3	79	18.9	2.0	75
2	13.5	0.1	77	20.5		75
3	15.5	3.1	66	20.9		72
4	14.7		75	20.1	2.6	79
5	13.2	10.3	91	19.1	4.4	80
6	7.4	20.7	93	19.3	0.0	78
7	8.6		76	22.2	0.3	73
8	11.4		68	23.6		68
9	9.8	3.0	81	24.4		68
10	12.7	11.7	86	25.7		61
11	14.9	0.2	77	24.7		63
12	17.4		58	25.2		65
13	16.9	0.0	67	26.5		58
14	11.2	1.3	85	26.6		68
15	11.0	1.6	92	27.2		63
16	12.9		79	26.8		64
17	15.2		75	22.9	15.4	78
18	18.1		73	23.5		71
19	19.0	0.0	72	23.6	0.2	74
20	17.5	2.3	74	23.3	0.9	72
21	15.8	3.7	79	21.7	28.7	81
22	15.5	8.1	81	22.6		76
23	14.0	0.4	89	22.5	0.4	81
24	15.4	1.1	89	21.3	4.1	82
25	17.4	2.1	80	25.4		64
26	19.9		70	25.8		68
27	18.9		76	22.7	60.3	78
28	17.6	10.7	89	20.4		68
29	18.0	2.7	82	20.0		56
30	16.3	12.9	92	21.8		64
31	17.2	1.5	81	-	-	-
Average/sum	14.8	105.8	79.1	23.0	119.3	70.8
Multi-annual averages	10.4	46.3	70	15.8	61.6	78

In table 2 are presented some morpho-phisyological characters of the genotypes tested, with possible implications in attack degree of *Fusarium*.

The number of plants/m^2 varied between 319 and 427 and the number of ears/m^2 between 461 and 586. Date of earring varied between May 7 and May 18. At the first look, it seems that there is no correlation with *Fusarium* attack (visual estimation by notes or % of ears with symptoms of damaged). In accordance with notes, it seems that the genotypes: Otilia and Dacic are the list affected by FHB. Estimating the extension of symptoms on ears (in %), the same genotypes and in addition: Ursita, F14.078 GP 1 were the more resistances.

Table 2

Morpho-phisyological characters of the tested genotypes.
Oradea, 2019.

Nr. Crt.	Genotype	Density/ m^2		Date of earring	*Fusarium* head blight (notes)	% of ears attacked
		plants	ears			
1	GLOSA	400	497	**7/05**	4/5	33.5
2	BOEMA	424	512	9/05	3.7/5	24.4
3	LITERA	335	473	10/05	.7/6	35.9
4	MIRANDA	357	461	9/05	4.7/6	31.8
5	IZVOR	320	566	9/05	5.7/6	26.3
6	OTILIA	380	497	11/05	**3/3**	13.7
7	PITAR	324	476	10/05	7/7	34.3
8	PAJURA	337	541	9/05	5.3/6	29.4
9	SEMNAL	355	494	12/05	5/5	29.9
10	URSITA	329	541	10/05	3/4	17.0
11	VOINIC	345	552	12/05	3.7/4	22.6
12	ZAMFIRA	319	522	12/05	3.7/4	25.4
13	AMURG	393	520	8/05	6/7	35.5
14	ARMURA	372	521	14/05	4/4	28.0
15	ABUNDENT	397	537	13/05	3.7/4	21.3
16	F14.078 GP 1	**427**	564	12/05	3/3.7	9.9
17	A4-10	379	553	14/05	7/8	35.1
18	ADELINA	401	578	11/05	4.3/5	28.4
19	ȘIMNIC 60	373	532	13/05	4/5	33.3
20	DACIC	363	553	**18/05**	**3.3/4**	16.1
21	LV. 5X	415	524	14/05	5.7/6	36.6
22	LV. 9T	384	557	15/05	6.7/8	38.2
23	LV. 6107	383	548	13/05	6.7/7	30.0
24	LV. 6111	391	**586**	13/05	5.7/6	29.9
25	BEZOSTAIA	345	548	17/05	4/4	24.3
Averages		370	530.4	11/05	4.7/5.4	27.6

In these circumstances, the yield levels of the genotypes (table 3) varied between only 3630,6 Kg/ha (Izvor) and 5936.0 kg/ha (F. 14.078 GP 1, a breeding line created at NARDI Fundulea). The average of experiment was 4900.3 kg/ha, less than the last years, just for the damages caused by FHB. It is important to underline that the breeding line F. 14.078 GP 1 was the most resistant to *Fusarium* damages, estimated by % of ears attacked. Other genotypes (Otilia, Dacic and Abundent) were in the same time very yielding and resistant, too.

The best yielding and FHB resistant genotypes are new creations, obtained during the last years at NARDI Fundulea and ARDS Lovrin, by selection in natural or artificial conditions of infection with *Fusarium*.

Table 3

Results regarding the yield of some winter wheat genotypes.
Oradea, 2019

Class.	Genotype	Yield		Differences (kg/ha)	Significance of differences
		kg/ha	relative (%)		
1	F. 14.078 GP 1	5936.0	121.1	+1035.7	***
2	ABUNDENT	5865.2	119.7	+964.9	***
3	OTILIA	5743.2	11.2	+842.9	**
4	DACIC	5660.8	115.5	+760.5	**
5	VOINIC	5491.6	112.1	+591.3	*
6	LOVRIN 5X	5447.6	111.2	+547.3	*
7	ARMURA	5239.8	110.2	+339.5	
8	BOEMA 1	5187.5	105.9	+287.2	
9	MIRANDA	5008.9	102.2	+108.6	
10	LOVRIN 6111	4999.9	102.0	+99.6	
11	SEMNAL	4979.3	101.6	+79.0	
12	ZAMFIRA	4977.7	101.5	+77.4	
Experimental average		**4900.3**	**100,0**	**0**	**-**
13	URSITA	4892.8	99.8	-7.5	
14	ȘIMNIC 60	4848.9	99.0	-51.4	
15	LOVRIN 6107	4782.6	97.6	-117.7	
16	A 4-10	4738.7	96.7	-161.6	
17	ADELINA	4671.2	95.3	-229.1	
18	GLOSA	4619.2	94.3	-281.1	
19	PITAR	4613.5	94.1	-286.8	
20	LOVRIN 9T	4483.5	91.5	-416.8	
21	PAJURA	4318.3	88.1	-582.0	o
22	LITERA	4202.2	85.8	-698.1	o
23	BEZOSTAIA	4105.7	83.8	-794.6	oo
24	AMURG	4062.8	82.9	-837.5	oo
25	IZVOR	3630.6	74.1	-1269.7	ooo

LSD $5_{\%}$= 521.1 Kg/ha;
LSD $1_{\%}$= 706.2 Kg/ha;
LSD $0.1_{\%}$= 945.5 Kg/ha.

In table 4 are presented the correlations calculated for all characters evaluated, for all 25 genotypes. The yield correlated positive with plant density and number of grains/ear and negative with *Fusarium* head blight and test weight (hectolitre mass). It can concluded that FHB caused the diminished of grains weight and in consequence a reduced yield. Wheat dwarf virus (WDV) did not influenced significant the yield and some morphological or physiological characters, but brown rust caused the diminished the thousand kernel weight (TKW).

Table 4

The correlations between morphological and physiological characters in wheat. Oradea, 2019

Nr. Crt.	Characters	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Yield	1	**0.45***	-0.19	0.32	-0.13	-0.34	0.10	**-0.56**^{oo}	-0.23	0.01	**0.53****	0.01	**-0.41**^{o}
2	Plants density		1	-0.16	0.06	0.02	-0.05	0.23	-0.02	-0.12	0.21	-0.06	-0.16	0.01
3	Height			1	**0.48***	-0.17	**-0.51**	0.38	-0.20	0.10	0.06	-0.24	-0.09	0.14
4	Date of earring				1	-0.01	**-0.90**^{o}	**0.70****	-0.10	-0.24	**0.43***	0.08	-0.32	0.01
5	Maturity					1	**0.44***	0.14	0.24	0.15	0.31	-0.15	-0.12	0.20
6	Grain fill period						1	**-0.57**^{oo}	0.19	0.28	-0.25	-0.14	0.23	0.08
7	Brown rust							1	0.28	0.03	0.29	0.03	**-0.61**^{oo}	0.22
8	FHB								1	0.19	-0.01	-0.36	**-0.56**^{oo}	0.27
9	WDV									1	-0.03	-0.19	-0.09	-0.01
10	Ears density										1	-0.37	0.15	-0.04
11	grains/ear											1	-0.18	-0.15
12	TKW												1	-0.01
13	Test weight													1

N = 25; $r_{5\%} = 0.40$; $r_{1\%} = 0.52$.

More suggestive are the graphical presentation of trend line between the studied factors. In figure 1 is presented the polynomial regression (the most representative from 5 types of regression) between yield and *Fusarium* attack (intensity). More significant (R^2= 0.5378**) were the regression between fusarium attack, evaluated by % of ears affected by whitened, from total number of ears.

Figure 3 presents the effect of *Fusarium* on grains diminution mass (TKW), a crescent intensity of attack affected the gains mass.

The evaluation of wheat genotypes resistance by notes or by % of ears whitened seams to be equal (figure 4). This fact is most important in breeding activity when we have to evaluate the reactions to disease of thousands descendents.

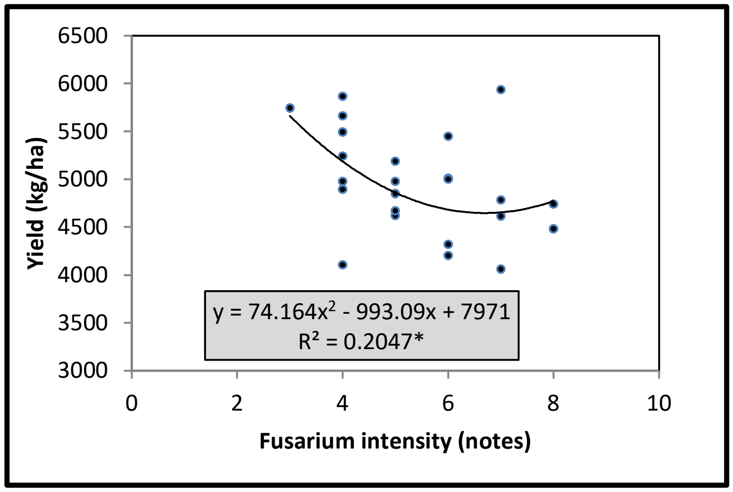

Fig. 1 The regression between *Fusarium* intensity and yield of genotypes

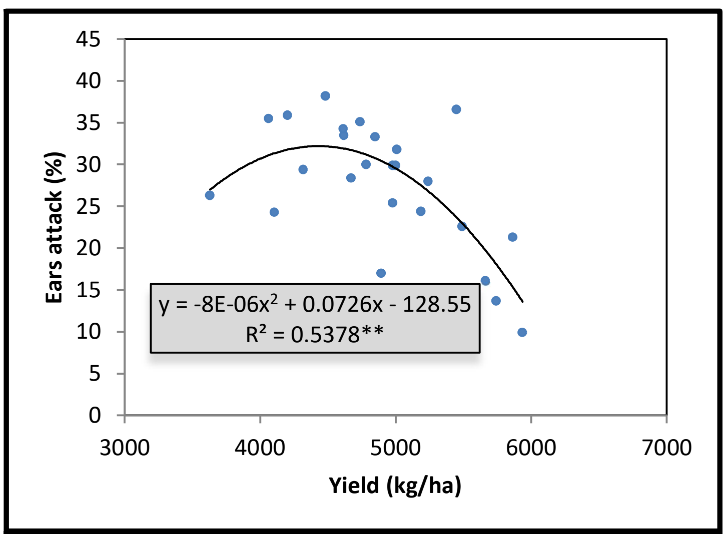

Fig. 2 The regression between ears attack by *Fusarium* and yield of genotypes.

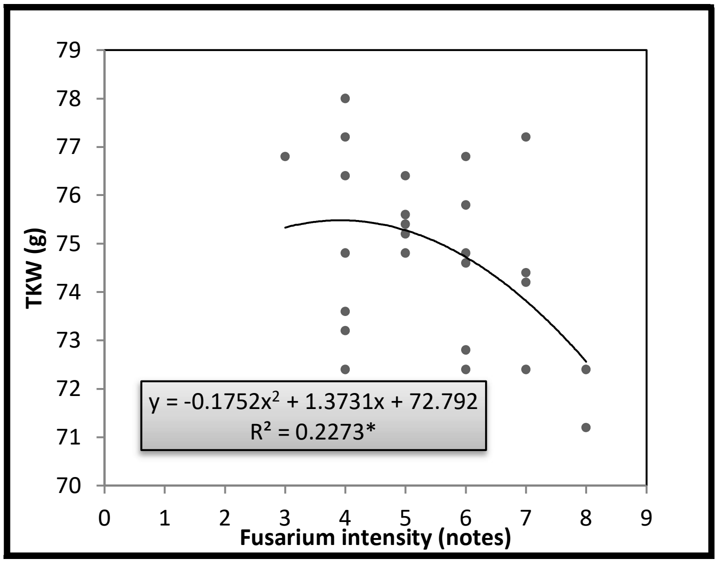

Fig. 3 The relationship between *Fusarium* intensity and TKW

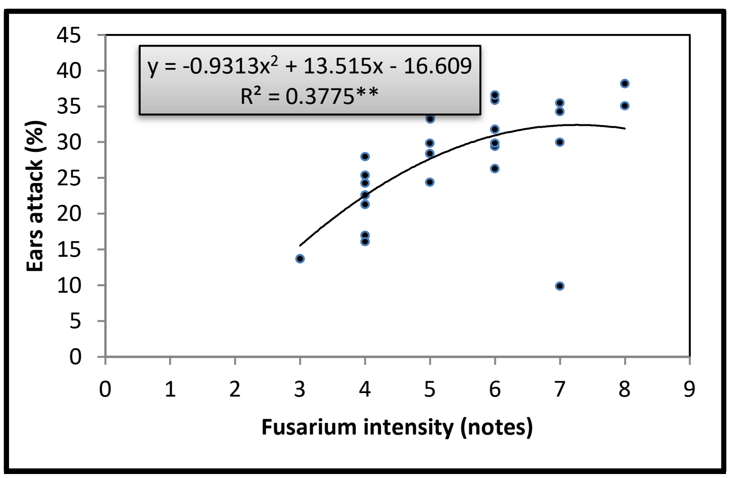

Fig. 4 The relationship between *Fusarium* intensity and ears attack

CONCLUSIONS

The unusual attack of *Fusarium graminearum* during the year 2019 permitted the estimation of genotypes reaction to this disease.

The less affected genotypes were: F. 14.078 GP 1, Otilia, Dacic and Abundent, all of them being new creations.

The most affected by *Fusarium* attack is gains mass and implicitly yield.

In estimating genotypes resistance to *Fusarium* attack, the numbers of ears affected (in %) or intensity attack (evaluated by notes), have the same importance.

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