RESULTS REGARDING THE *FUSARIUM* ATTACK ON SOME WINTER WHEAT VARIETIES, IN CORELATION WITH NITROGEN FERTILIZATION

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Abstract
In the lasts decades, the Fusarium head blight become the most damaged disease of wheat, especial during the rainy springtime. The year 2010 was one of these types, especial in western Romania. It was an opportunity for us to study this disease, in natural infection conditions.
Our results stand out the superior resistance of some varieties (Josef, Kristina, Apache and Litera), appreciate by fervency, intensity and attack degree. By the correlation method, we determined that the varieties with great spike densities are more affected by the attack. Also, the attack parameters correlate in variants fertilized and unfertilized with nitrogen, demonstrating that, even the attack is greater in fertilized variant, the susceptible varieties have the same reaction with low nitrogen fertilization. Information confirmed in this experiment is that the quality of seeds (wet gluten, total proteins and sedimentation index) are depending of fusarium attack intensity.

Key words: fusarium head blight, wheat, variety, resistance.

INTRODUCTION

Wheat is most important cereal crop in Europe, being cultivated on over 16 million ha and yielding over 88 million metric tons per year (Ruckenbauer and all, 2007). The wheat quality and consumer safety is threatened by *Fusarium* Head Blight (FHB) caused by *Fusarium culmorum, Fusarium graminearum and Fusarium avenaceum.* Most of the winter wheat varieties cultivated today in Europe are susceptible to this disease.

The *Fusarium* susceptibility of most Europeans cultivars is the basic cause of the irregularly occurring severe epidemics. Beside yield and quality loss, the toxin contamination is the major threat (Mesterházy, 2001).

In Romania, after 1975, the begin of cultivation of intensive wheat varieties, the damages exceeded frequent 50% in large areas, when the fungus *Giberella zeae (*Schw. Petch.), conidian form *Fusarium graminearum* Schw. meet optimal climatically conditions (Bunta Gh. and Bunta, 1992). In Crisana county, the disease caused great damages in 1970, 1985, 1987 (Bunta, 2003) and more recent in 2010, its apparition and intensity being very irregular.

The researches regarding the breeding of wheat for resistance to this disease are very difficult, the major causes being:

- Existence of a great number of *Fusarium* species and races, with large adaptability capacities;
- Inexistence of a standardized method for evaluation of resistance;
- Variable reaction of genotypes to disease attack, depending of year and areas;
- Up to the present, the genetic source of immunity to *Fusarium* head blight was not identified;
- The fungus is not obligated parasite it is able to survive saprophyte on dead lives and culms like mycelium, conidia, ascosporous.

For this reason, some researchers tried to elaborate some methods based on artificial infection with *Fusarium* (Mesterházy, 1984; Bunta Gh. and Bunta A., 1992; Mesterházy, 1995). Like an argument, Mesterházy establish that dwarf genotypes were more severely infected by head blight that a tall genotypes under natural conditions, but they were similarly susceptible after artificial inoculations.

In European Union are developed a project, FUCOMYR, with 6 countries cooperating. Three genomic regions were found to be significantly associated with *Fusarium* head blight (FHB) resistance: the most prominent effect was detected on the short arm of chromosome 3B, explaining up to 60% of the phenotypic variance for type II resistance. A further QTL was located on chromosome 5A and a third one on 1B (Ruckenbauer and all, 2007). These results indicate that FHB resistance is under control of a few major QTL's operating together with an unknown number of minor genes.

The FHB resistance QTL region of wheat chromosome 2DS flanks the reduced height gene Rht 8, which might influence initial infection of FHB under the field conditions (Handa and Ban, 2008). However, it is suggested the existence of other potential resistance genes within this QTL region.

The most favorable scenario for integration is the incorporation of Fhb 1 from Asian cultivars into adapted material with good native resistance, high yield and test weight, with superior milling and backing quality (Guedira and all, 2008). The highly resistant materials solve all problems, including DON (deoxynivalenol), the very dangerous toxin for animals and human health (Mesterházy, 2001).

The sources for resistance to *Fusarium* head blight (FHB) presents in breeding line RCATL 33 (realized from Tamburic-Ilincic and all, 2005) were Sumai 3 from China and Frontana from Brasil. This line is tall (120 cm) and it is lacking a high yield potential, so it can not be registered like a cultivar, but it is useful for FHB resistance breeding. Another well known resistant genotype is Nobeoka Bozu (from Japan).

A new source of resistance to FHB, realized recently in Canada, is a series of four synthetic hexaploid spring wheat (x*Aegilotriticum* sp.) lines (Berzonsky and all, 2003). They broaden the genetic base of resistance to *Fusarium.* The breeding synthetic lines are disponible now to breeders like a source to resistance.

Our present study tries to identify the possible sources of resistance to FHB and to explain some interactions between it and another diseases and plants characters.

MATERIAL AND METHODS

The experiments were conducted in the experimental field of Agricultural Research and Development Station Oradea during the year 2009-2010 and it consist in 25 winter wheat varieties, Romanian (18), Hungarian (2), Serbian (1), and Austrian (2) and from France (2). This kind of experiments is usual in our country, looking to establish the best cultivar for every area.

Regarding the climatically conditions, we must to underline the extremely raining spring and summer, respectively the sum of precipitation in May was 118.9 mm and in June was 82.8mm. The rain fall exceeded the normal average during the months April, May and June, that facilitating the apparition and speeding of life and ear diseases. It is significant that the sum of precipitations from August to July exceeded 840 mm, unusual for our region. In addition, the relative humidity of air oscillated between 74 and 96% and the sun bright only 185 hours in May. In these conditions, the diseases have high intensity.

. The 25 variants (varieties) were tested in a Lattice square balanced method, in 6 replications, three fertilized and the other three unfertilized with nitrogen (100 kg active substance/ha). The results were statistical processed by ANOVA (analyze of variance) and LSD (limit standard difference), correlations and regressions methods.

The attack of diseases was appreciated by notes, in FAO system, by percents (fervency, intensity and attack degree).

RESULTS AND DISCUSSION

The results regarding yield potential of variants, well ensured with nitrogen, are presented in table 1.

Table 1

Grain yield of some winter wheat varieties tested at Oradea in 2009/2010.
(Fertilized)

Class.	Variety	Yield (kg/ha)	Relative yield (%)	Differences to experimental average (kg/ha)	Significance of differences
1	Apache	9027	127.0	+1921	***
2	Ciprian	8568	120.6	+1462	***
3	Litera	7735	108.9	+629	
4	Izvor	7669	107.9	+563	
5	Faur	7647	107.6	+541	
6	Glosa	7450	104.8	+344	
7	Serina	7365	103.6	+259	
8	Kristina	7334	103.2	+228	
9	Capo	7312	102.9	+206	
10	Miranda	7301	102.7	+195	
11	Romulus	7219	101.6	+113	
12	Boema	7191	101.2	+85	
13	Dropia	7113	100.1	+7	
Experimental average		**7106**	**100.0**	**0**	**-**
14	Flamura 85	7102	99.9	-4	
15	Renesansa	7101	99.9	-5	
16	Kiskun Gold	6921	97.4	-185	
17	Lovrin 34	6883	96.9	-223	
18	Ardeal	6805	95.8	-301	
19	Alex	6680	94.0	-426	
20	Delabrad	6791	95.6	-315	
21	Gruia	6613	93.1	-493	
22	Crisana	6108	85.9	-998	o
23	Briana	6059	85.3	-1047	o
24	Ariesan	5946	83.7	-1160	oo
25	Josef	5709	80.3	-1397	oo

$LSD_{5\%}$ = 780 Kg/Ha; $LSD_{1\%}$ = 1057 Kg/Ha; $LSD_{0,1\%}$ = 1415 Kg/Ha.

The level of products is bigger than usual. The results are statistical ensured, the cultivars Apache and Ciprian being very significant better comparative to experimental average (7.106 kg/ha). The good results performed four new Romanian cultivars (Litera, Izvor, Faur and Glosa), with yields up to 7450 kg/ha.

The relative great values of LSD are explained by the fall of plants, caused especially by the fact that they were taller with 10-15 cm comparative to the last year, the explanation of excess reining during the springtime (April, May and the beginning of June.

We have the mention that the best yielding varieties were the lowest in the quality parameters (wet gluten, total protein, sedimentation index).

The densities of ears were good, with values between 512 (Kristina) and 760 (Capo), with an average of 624 ears/square meter. According with this

big density, the number of ears affected by *Fusarium* head blight is, in absolute values, big, the average of experiment being 159.7/ m^2 (table 2).

Table 2

Results regarding the *Fusarium* head blight in fertilized variant (Oradea, 2010)

Variety	Total ears /m^2	Ears with FHB / m^2	*Fusarium* head blight			
			Notes	Frequency (%)	Intensity (%)	Degree of attack (%)
Flamura 85	568	152	4	26.7	40	10.7
Lovrin 34	664	220	5	33.1	65	21.5
Ariesan	704	256	6	36.4	55	20.0
Dropia	536	152	4	28.4	35	9.9
Alex	664	160	2	24.1	60	14.5
Ardeal	640	160	2	25.0	75	18.7
Romulus	536	188	6	35.1	80	28.1
Boema	696	260	5	37.4	72	26.9
Delabrad	668	248	3	37.1	38	14.1
Faur	520	156	3	30.0	35	10.5
Glosa	624	200	4	32.1	40	12.8
Gruia	644	112	3	17.4	40	7.0
Izvor	688	216	3	31.4	70	22.0
Ciprian	704	224	3	31.8	55	17.5
Briana	520	60	4	11.5	68	7.8
Serina	688	88	3	12.8	65	8.3
Capo	760	256	5	33.7	72	24.3
Apache	636	80	2	12.6	43	5.4
Josef	624	20	2	3.2	18	0.6
Kristina	512	40	3	7.8	48	3.7
Kiskun Gold	692	116	3	16.8	66	11.1
Renesansa	696	156	4	22.4	77	17.2
Crisana	528	108	3	20.5	50	10.2
Litera	488	108	4	22.1	25	5.5
Miranda	600	256	6	42.7	70	29.9
Averages	**624**	**159.7**	**3.68**	**25.3**	**54.5**	**14.3**

The least affected were the varieties: Josef, Kristina, Apache, Briana and Serina, with values below 100 affected ears. The most affected were the varieties: Boema, Miranda, Capo and Ariesan, with values up to 250 ears affected.

Appreciating the *Fusarium* attack by notes (FAO system), the most resistant variety were Apache, Josef and Kristina (appreciates by 2), respectively the most susceptible were Lovrin 34, Gruia and Capo.

The frequency of ears affected by *Fusarium* attack was very big in case of the varieties Dropia, Boema, Faur and Romulus, but the intensity of attack vas different. With the greatest intensity values of attack were: Apache, Miranda, Kiskun Gold, Capo, Romulus, and Ariesan.

The degree of attack, being a synthetic indicator, is more important than the other two. According with this, the varieties with good reaction to *Fusarium* attack are: Josef, Kristina, Apache and Litera, with values under 10%.

In the variant with no nitrogen fertilization (table 3), all the values are less than in the variant with 100 kg/ha nitrogen (active substance). Even the values of attack are less, the varieties classification are the same. That means that the resistance to *Fusarium* attack is under genetic control.

Table 3

Results regarding the *Fusarium* head blight in no fertilized variant (Oradea, 2010)

Variety	Total ears /m^2	Ears with FHB/ m^2	*Fusarium* head blight			
			Notes	Frequency (%)	Intensity (%)	Degree of attack (%)
Flamura 85	492	68	4	13.8	60	8.3
Lovrin 34	428	136	6	31.8	62	19.7
Ariesan	596	112	5	18.8	72	13.5
Dropia	444	144	4	32.4	50	16.2
Alex	456	76	3	16.7	45	7.5
Ardeal	388	68	3	17.5	70	12.2
Romulus	452	176	5	38.9	78	30.3
Boema	536	200	5	37.3	66	24.6
Delabrad	468	112	4	23.9	45	10.8
Faur	444	144	3	32.4	40	13.0
Glosa	420	100	5	23.8	44	10.5
Gruia	464	36	6	7.8	25	1.9
Izvor	532	104	3	19.5	62	12.1
Ciprian	648	124	4	19.1	46	8.8
Briana	528	32	4	6.1	27	1.6
Serina	588	76	3	12.9	67	8.6
Capo	496	76	6	15.3	72	11.0
Apache	600	36	2	6.0	80	4.9
Josef	524	56	2	10.7	27	2.9
Kristina	444	24	2	5.4	62	3.3
Kiskun Gold	504	72	4	14.3	73	10.4
Renesansa	484	88	4	18.2	56	10.2
Crisana	488	52	3	10.7	40	4.3
Litera	420	64	4	15.2	38	5.8
Miranda	368	76	5	20.7	72	14.9
Averages	**488.5**	**90.1**	**4**	**18.8**	**55**	**10.7**

Trying to understand the implications of *Fusarium* attack on yield and its quality, we calculated the correlations between the elements of attack and yields of grains, grains damage and seeds germination (table 4). The varieties with great densities had intensity and attack degree greatest. Like evidence, intensity, frequency and attack degree correlate very strong. The

seed germination is negative affected by frequency of attack. The percent of grains sick is strongly dependent of attack degree.

Comparative to no fertilized variant, the correlation indexes are positives and significant.

Table 4

The correlations between FHB and grain yield.
Oradea, 2010, fertilized.

	Character	2	3	4	5	6	7	8	No fertilized
1	**Total ears**	0.255	0.414*	0.409*	0.070	0.099	0.041	-0.001	0.434*
2	**Frequency**	-	0.323	0.838***	-0.441*	0.200	0.049	0.115	0.725**
3	**Intensity**		-	0.731**	-0.116	0.153	0.069	0.019	0.580**
4	**Attack degree**			-	0.207	0.310	0.169	0.708**	0.952**
5	**Germination**				-	-0.010	0.020	-0.057	0.078
6	**Total grains yield**					-	-0.009	0.671**	0.495*
7	**Healthily grains yield**						-	-0.822**	-0.540**
8	**Grain damage %**							-	0.265

R5% = 0.39; R1% = 0.51.

In the climatic conditions described anterior, other diseases were presents: powdery mildew, septoria and leaf rust (Table 5). All the FHB indicators correlated significant with powdery mildew. That means that the varieties susceptible to FHB are susceptible to *Erisiphe graminis,* too. The same climatic conditions facilitate the apparition end evolutions of both diseases.

Table 5

The correlations between FHB and other diseases.
Oradea, 2010, fertilized.

	Character	Precocity	Powdery mildew	Septoria	Leaf rust	FHB notes
1	**Frequency**	-0.202	0.426*	-0.346	-0.246	0.642**
2	**Intensity**	-0.060	0.485*	-0.010	-0.086	0.374
3	**Attack degree**	-0.067	0.513**	-0.188	-0.246	0.669**
5	**FHB notes**	-0.331	0.181	-0.218	-0.132	-
6	**Leaf rust**	-0.068	0.229	-0.200	-	
7	**Septoria**	0.095	-0.182	-		
8	**Powdery mildew**	0.035	-			

R5% = 0,39; R1% = 0,51.

Like an expression of genetic control of resistance to FHB and to the stability reaction, the regression line between attacks in the two conditions is very suggestive (figure 1). The general trend is the same, but at the different level.

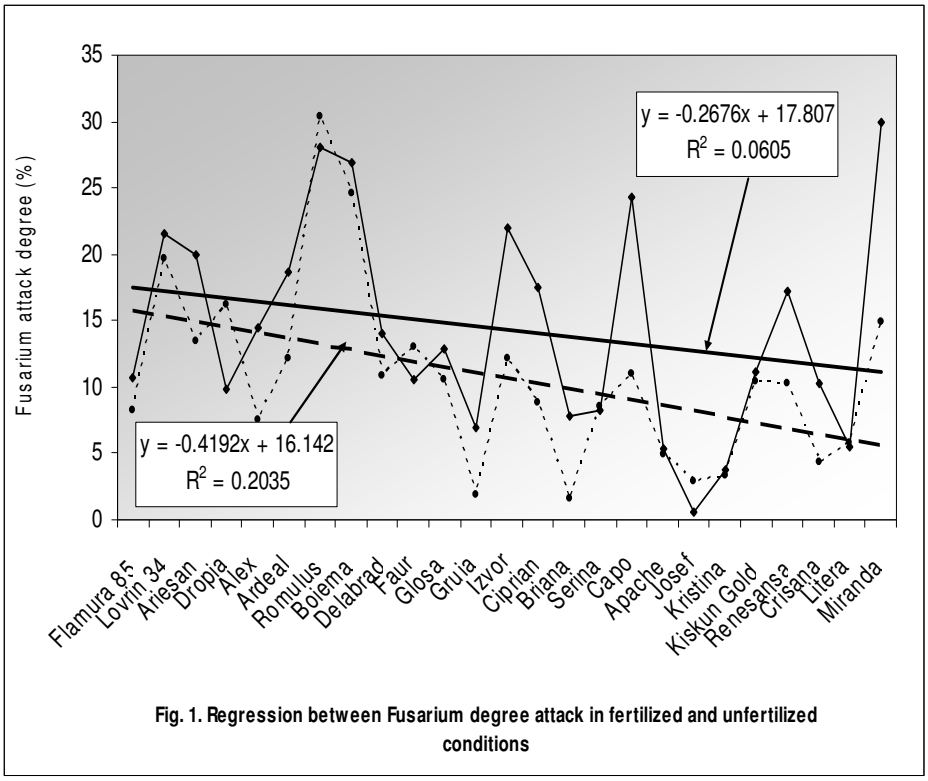

Fig. 1. Regression between Fusarium degree attack in fertilized and unfertilized conditions

In figure 2, the linear regression between the intensity attack and the sedimentation index explained in a clear manner the effect of depreciation the quality of yield.

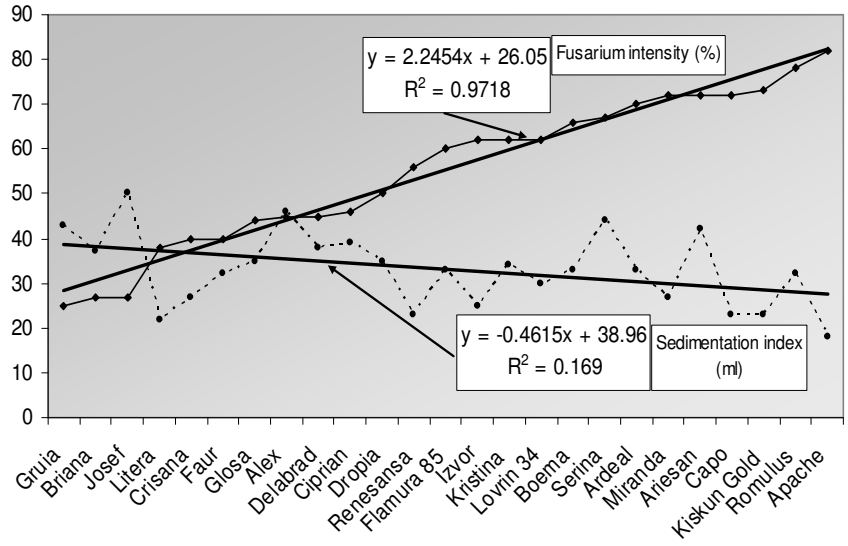

Fig. 2. Regression between Fusarium intensity attack and sedimentation index (unfertilized)

CONCLUSIONS

1. The least affected varieties by FHB were: Josef, Kristina, Apache, Briana and Serina and the most affected were: Boema, Miranda, Capo and Ariesan.
2. The nitrogen fertilization affects the level of attack, but not the varieties classification of resistance. This suggests a strong genetic control of resistance to *Fusarium*.
3. The attack frequency and intensity are facilitating by a big ears density.
4. The quality of yield, like seed germination and sedimentation index, are strong affected by FHB attack.
5. The reaction of varieties to *Fusarium* attack is similar for powdery mildew, but not for *Septoria* sp.

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