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INFLUENCE OF SOME AGRONOMY FACTORS ON SPIKE COMPONENTS AFTER A RARE INCIDENCE OF FUSARIUM HEAD BLIGHT EPIPHYTOTY OF WINTER WHEAT II. EFFECT OF POST-HARVEST RESIDUE INCORPORATION

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Abstract

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The investigation was carried out in a stationary agronomy trial in the spring of 2005. The year was characterized with a rare fusarium epiphytoty on common winter wheat. The experiment was performed in the trial field of Dobroudja Agricultural Institute – General Toshevo (North-East Bulgaria) with the aim to evaluate the effect of total fusarium infection on the spike components of winter wheat as influenced by the agronomic factors post harvest residues incorporation (PHR), mineral fertilization and previous crop.The variants of the trial were the following: A_0 – growing of wheat without incorporating PHR of the previous crop and A_1- growing of wheat with incorporation of the preceding PHR. In this PHR background, mineral fertilization was applied at rates N_0P_0 and $N_{120}P_{120}$ (kg/ha). It was established that the highest severity of infection was determined after previous crop maize fertilized with nitrogen rate $N_{120}P_{120}$. Incorporation of PHR also had a significant negative effect on the number of infected spikes per unit area. The value of the PHR harmful effect on this index was 1.2 infected spike/m^2 more than in the check (A_0) regardless of the fertilization variant. Depending on the type of previous crop, the harmful effect of the incorporated PHR was most evident after maize – 2.1 infected spikes per m^2 more than in the check variant. The biometrical analyses on the spike components showed that grain weight per spike was influenced only by the type of previous crop. PHR did not have a noticeable effect on the number of grains per spike. The index 1000 grain weight was similarly affected, the effect of the previous crop being again most significant.

Key words: wheat – fusarium – post-harvest residues – fertilization – previous crop

Introduction

Fusarium on spikes caused by the fungus *Fusarium graminearum* (Schwabe) is one of the most dangerous diseases on wheat and barley due to its great harmful effect on crops. This harmful effect is especially evident when there is a combination of favourable factors: suitable agrometeorological conditions, abundant previous crop post-harvest residues (PHR), as well as PHR type (Backhouse et al., 2000, Cottent and

Munkvold, 1998; Gilchrist et al., 1997). Fusarium-infected wheat strongly decreases its yield, and grain and flour quality worsen due to harmful toxins in them (Munkvold, 2004).

To keep the damages caused by this disease under the economic threshold of harmfulness, it is necessary to apply crop rotations with PHR not suitable hosts for the pathogen (Bai and Sganer, 2004; Dill-Macky and Jones, 2000; Dormaar and Garefoot, 1996; Simeonov, 1973; Smolinska, 2000). The way of pre-sowing soil tillage is also significant for control of the disease. Deep tillage is recommended with a view of good mixing of PHR with the soil thus creating conditions for intensive decomposition through soil micro flora (Burgess et al., 1996; Dimitrov, 1997; Gushevilov, 1998; Rasmussen et al., 1997; Toussoun, 1963; Wang, 1999).

Mineral fertilization plays a specific role among the factors favorable for the occurrence and epiphytoty of the disease. Previous crops of wheat abundantly fertilized with nitrogen are a prerequisite for the accumulation of post-harvest substrate rich in nutrients. The direct intensive nitrogen fertilization leads to formation of dense and lush crops with delicate and succulent plants easily susceptible to infection.

The sowing terms, the long-term rotation of the same crops (Tonev et al., 2007), as well as the respective use of chemical plant protection are also significant for the occurrence or lack of occurrence of fusarium on wheat. The aim of this study was to evaluate the effect of total fusarium infection on the spike components of winter wheat as influenced by the agronomic factors PHR incorporation, mineral fertilization and previous crop.

Material and Methods

The investigation was carried out in the spring of 2005, when a rare epiphytoty of fusarium on spikes occurred against natural background of fusarium on PHR of maize, beans and sunflower. The epiphytoty was favored by a specific combination of meteorological factors and phenological development of common winter wheat.

Spikes from common winter wheat variety Enola were investigated in a long-term stationary field trial, the main aim of which was to follow the effect of systematic PHR incorporation on productivity in crop rotation. The trial was initiated in 1994, growing wheat after previous crops dry bean, grain maize and sunflower. The trial was designed by the split-split-plots method. The main plots were the two variants of PHR treatment. The subplots were respectively representative of the different previous crops and fertilization rates. The size of the harvest plot was 25 m^2. The variants of the trial were the following: A_0 – growing wheat without post-harvest residues (PHR) incorporation (PHR was removed from the field) and A_1 – growing wheat after incorporation of the entire PHR of the previous crop. PHR of dry bean, maize and sunflower was chopped into pieces by the harvester cutter and spread on the field area. PHR were incorporated not very deep in soil during autumn pre-sowing tillage (disking) at depth 10-12 cm. In these two PHR backgrounds, mineral fertilization with the following elements and two rates was used: N_0P_0 and $N_{120}P_{120}$. All other elements of wheat growing were in accordance with the technology for wheat cultivation accepted for this agro-ecological region (Klochkov et al., 1988).

Having registered severe fusarium infection on wheat and the typical white spikes, on 17th June 2005, 5 healthy and 5 infected spikes were marked from three replications per variant, respectively. The reading of number of infected spikes per j m^2 was done similarly. The marked spikes were harvested at maturity stage. Biometrical analysis was performed on the spikes to determine the number and weight of grain per spike, as well as 1000 grain weight.

ANOVA was applied to find out significant differences between control variant and independent effects of the studied factors using the statistical software BIOSTAT© (Penchev et al., version 1.0).

Results and Discussion

Heading and anthesis of wheat in the spring of 2005 occurred later than usual in the region of Dobroudja –

during the third decade of May. This coincided with a period of alternation of high (up to 29.0 °C) and low (9.8 °C) air temperatures, rainfalls (24.9 mm for the period 21-31 May) and high relative air humidity (82.6 %). The humid summer of 2004 was the reason for the high yields from the previous crops and the respective high amounts of PHR. These conditions contributed to a natural fusarium infection background further intensified by the forest belts protection in the region making the fields poorly aerated. The ultimate result was a rare fusarium epiphytoty on wheat spikes.

Two weeks following the infection, a visible effect was noticed in the crop. "White" spikes were observed: less in the variant without fertilization and significantly more in the variant fertilized with nitrogen.

PHR incorporation had a negative effect on the infection status of the spikes per unit area (Tables 1). Its harmful effect was most evident after maize PHR (+1.6 spikes per m^2), followed by sunflower PHR (+1.2 spikes per m^2) and dry bean PHR (+0.6 spikes per m^2).

The harmful effect of nitrogen fertilization on the infection severity depending on the previous crop could be arranged in the following descending order: dry bean (+2.5 spikes per m^2) > sunflower (+3.9 spikes per m^2) > maize (+5.8 spikes per m^2). The independent effect of the respective predecessors on disease development was also well differentiated. Highest number of infected spikes (5.7 spikes per m^2) was determined after previous crop maize and lowest – after previous crop dry bean (3.6 spikes per m^2).

The harmful effect of the first factor (PHR incorporation) on the spike infection severity can be explained by the high accumulation of infection under the favourable conditions for occurrence of fusarium in this variant.

The type of PHR depending of the previous crop was also significant for the harmful effect of the pathogen: maize PHR was the carrier of highest infection pressure. The negative effect of mineral fertilization was mostly due to nitrogen which favoured the formation of a crop with higher density, more tender and succulent plants therefore more susceptible to infection.

Table 1
Number of visibly fusarium-infected spikes per 1 m^2 depending on the type of PHR treatment, mineral fertilization and previous crop

PHR use	NP rate	Previous crop			Average for respective NP rate
		Dry bean	Maize	Sunflower	
Without PHR incorporation	N_0P_0	2.1	2.4	2.2	2.2
	$N_{120}P_{120}$	4.5	7.5	5.5	5.8
	Average	3.3	4.9	3.9	4
Full PHR incorporation	N_0P_0	2.6	3.2	2.8	2.9
	$N_{120}P_{120}$	5.2	9.8	7.3	7.4
	Average	3.9	6.5	5.1	5.2
D ±		(+0.6)	(+1.6)	(+1.2)	1.2
Average for respective previous crop		3.6	5.7	4.5	

The significance of the PHR harmful effect independently from the other factors in the trial amounted to a mean of 1.2* spikes per m^2 more than in the check variant A_0. As already mentioned above, a well expressed differentiation was established in the severity of infection according to the PHR origin: bean (+0.6^{NS}) > sunflower (+1.2*) > maize (+1.6*). The independent negative effect of fertilization, regardless of the PHR treatment, was +4.1*** spikes per m^2, and that of the previous crop was respectively +2.1** spikes per m^2 (after maize) and +0.9^{NS} spikes per m^2 (after sunflower). The data show that the factor fertilization had the most harmful effect on the number of infected spikes per unit area. (Table 2)

The biometrical analyses on the spike components showed that grain weight per spike was not significantly affected by the factors PHR and fertilization. Grain weight per spike was influenced only by the

Table 2
Major effect of factors on the number of infected spikes per 1 m^2 crop

Studied factor	PHR treatment		D±
Factor A. PHR from:	A_0 – Control	A_1	
Dry bean	3.3	3.9	+0.6^{NS}
Maize	4.9	6.5	+1.6*
Sunflower	3.9	5.1	+1.2*
Factor B, Previous crops			
Bean, control	3.6		-
Maize	5.7		+2.1**
Sunflower	4.5		0.9^{NS}
Factor C. Fertilization			
N_0P_0 – Control	2.5		-
$N_{120}P_{120}$	6.6		4.1*

Notes:
A_0 – without PHR incorporation;
A_1 – with PHR incorporation
*, **, *** - significant differences according to the check variant for P levels 5, 1 %, respectively; ^{NS} – not significant differences

type of previous crop, the difference being 0.53* g after previous crops maize and sunflower in comparison to the check variant with previous crop bean.

PHR did not have a noticeable effect on the number of grains per spike (Table 3).

Wheat fertilization increased the number of grains in the visibly infected spikes in comparison to the check. The difference according to the check was +5.7** grains and was statistically significant.

Grain weight per spike did not change significantly under the effect of the first two factors in the trial – PHR and fertilization. This index was significantly affected only by the type of previous crop: absolute value -0.53* g after previous crops maize and sunflower according to the check predecessor bean.

The index 1000 grain weight was similarly affected, the effect of the previous crop being again most significant: -13*** g and -10.4 g after previous crops maize and sunflower, respectively. The decrease of 1000 grain weight in the visibly infected spikes after the above previous crops was several times higher than the decrease in the visibly healthy spikes.

Table 4 presents the yields in 2005 and averaged values for four previous years without infection. The analysis of the data obtained under various conditions during the two compared periods showed that grain yield increased insignificantly as a result from PHR incorporation. There was slight increase of yield as affected by PHR in both fertilization variants. The positive difference in favor of variant A_1 leads to the conclusion that it is a result from the higher effect of fertilization against the background of incorporated PHR. Therefore fertilization with $N_{120}P_{120}$, although increasing the number of visibly infected plants per unit area, is able to compensate the excessive yield decrease caused by fusarium due to a better nutrition regime.

The yield variations due only to fertilization during the two compared periods were especially evident in the variant with fertilization. These variations were noticeably negative for the yield obtained during the epiphytoty year (2005) and after the three previous crops.

The yields during 2005 were lower in comparison to the previous 4-year infection-free period. This yield decrease was to a large extend due, undoubtedly, to the fusarium infection on spikes, besides the other vegetation conditions characteristic for this year. This conclusion is based on the fact that the yields from the variants without fertilization obtained during the two periods were entirely comparable; after bean and sunflower the difference was positive and in favour of the 2005 yield. Evidently, the other conditions being the same, the combination “nitrogen fertilization x suitable previous crop PHR” is decisive for generating high infection background and subsequent mass infection on the wheat crop.

The importance of the PHR origin is demonstrated by the fact that even in the variants without fertilization the variation of the yield obtained after maize in 2005 was negative. This contradicts the data already

Table 3
Spike components of visibly healthy and visibly fusarium-infected wheat spikes according to type of PHR treatments, mineral fertilization and previous crop

Studied factors and their levels	Grain weight per spike,g			Number of grains per spike			1000 grain weight, g		
	Visibly healthy spikes	Visibly fusarium-infected spikes	In % to visibly healthy spikes	Visibly healthy spikes	Fusarium-infected spikes	In % to visibly healthy spikes	Visibly healthy spikes	Fusarium-infected spikes	In % to visibly healthy spikes
Factor A. Post-harvest residue (PHR) use									
A_0 – Control	1.5	1.08	72	39.6	35.3	89.1	39.8	30.6	76.9
A_1	1.62	1.05	64.8	40.6	36.9	90.8	39.8	28.4	71.3
D±	+0.12^{NS}	-0,03^{NS}	-	+1.0^{NS}	+1.6^{NS}	-	+0.01^{NS}	-2.2^{NS}	-
Factor B. Previous crop									
Dry bean – Control	1.69	1.42	84	39.2	36.4	92.8	43.1	39	90.5
Grain maize	1.58	0.89	56.3	39.1	34.1	87.2	40.4	26	64.3
D±	-0.11^{NS}	-0.53*	-	-0.1^{NS}	-2.3	-	-2.7*	-13.0***	-
Sunflower	1.65	0.89	53.9	40.7	31.1	76.4	40.5	28.6	70.6
D±	-0.04^{NS}	-0.53*	-	+1.5^{NS}	-5.3*	-	-2.6*	-10.4***	-
Factor C. Fertilization									
N_0P_0 – Control	1.53	1.09	71.2	39.1	33	84.3	39.1	27.8	71.1
$N_{12}P_{12}$	1.58	1.05	66.4	41	38.7	94.3	38.5	27.1	70.3
D±	+0.05^{NS}	-0.04^{NS}	-	+1.9^{NS}	+5.7**	-	-0.6^{NS}	-0.7^{NS}	-

Notes:
A_0 – without PHR incorporation; A_1 – with PHR incorporation
*, **, *** - significant differences according to the check variant for P levels 5, 1 and 0.1 %, respectively; ^{NS} – not significant differences

mentioned above concerning the other two previous crops in the same fertilization variant.

Conclusions

The effect of the incorporated PHR on severity of fusarium on spikes was on the whole negative, maize PHR being most harmful. Fertilization also had a significant negative effect on this index. The independent effect of the previous crop was similar to that of the PHR left after its application.

Among spike components, the index 1000 grain weight was most negatively affected by the previous crop. Sunflower and maize had well expressed negative effects. The decrease of this index's value in the visibly infected spikes after the above two previous crops was several times higher than the decrease in the visibly healthy spikes.

The other conditions being equal, the combination 'Nitrogen fertilization x Suitable type of PHR' was decisive for generating high infection background and subsequent mass infection on the wheat crop.

Table 4
Grain yield according to PHR treatment, previous crop and mineral fertilization, kg/ha

PHR use	Mineral fertilization	Previous crops								
		Dry bean			Grain maize			Sunflower		
		Averaged for 4 years	2005	Difference, ±D	Averaged for 4 years	2005	Difference, ±D	Averaged for 4 years	2005	Difference, ±D
A_0	N_0P_0	5300	5540	240	3680	3430	-250	4370	4470	100
	$N_{120}P_{120}$	7640	6240	-1400	7560	5750	-1810	7550	5990	-1560
	Average	6470	5890	-580	5620	4590	-1030	5960	5230	-730
A_1	N_0P_0	5480	5620	140	3600	3490	-110	4390	4410	20
	$N_{120}P_{120}$	7660	6350	-1310	7560	5880	-1680	7800	6460	-1340
	Average	6570	5990	-580	5580	4690	-890	6100	5440	-660
Mean for respective previous crop		6520	5940	-580	5600	4640	-960	6030	5330	-700

Note:
A_0 – without PHR incorporation; A_1 – with PHR incorporation

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