

## **Control of *Fusarium* head blight of winter wheat by artificial and natural infection using new fungicides**

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### **S u m m a r y**

In Latvia, climatic factors are influential in spreading of *Fusarium* head blight of cereals caused by *Fusarium* species. The most significant factor affecting the incidence of the disease in winter wheat is heightened temperature at the time of wheat anthesis. Field trials for the control of the disease in winter wheat were done in 2003-2004 using new fungicides applied at various rates by natural infection and artificial inoculation. Three species of causative agents: *Fusarium avenaceum* var. *herbarum*, *F. gibbosum*, *F. culmorum* were collected from infected seeds of wheat and used for inoculation of experimental plots at the concentration  $10^6$  conidia  $\text{ml}^{-1}$  (1:1:1) at the stage of full anthesis. Effective control of the disease was obtained through application of new fungicides with different active ingredient: Prosaro 250 EC (tebuconazole 125 G, prothioconazole 125 G  $\text{L}^{-1}$ ), Input 460 EC (spiroxamine 300 G, prothioconazole 160 G  $\text{L}^{-1}$ ). In conditions of artificial infection by severe attack of *Fusarium* spp. the application of fungicides containing tebuconazole at T3 gave significant influence on yield of winter wheat through plumpness of grains increase. High efficacy of fungicides against leaf infection with *Erysiphe graminis* and *Drechslera tritici-repentis* was also in the trial achieved.

Application of fungicide containing cyproconazole and trifloxystrobin at T1 in the trial 2004 gave good control of *Septoria tritici*, *E. graminis* and *D. tritici-repentis*.

Key words: winter wheat, *Fusarium* head blight, leaf diseases, fungicides, efficacy

## **INTRODUCTION**

*Fusarium* head blight of wheat in last years is a very important worldwide disease in intensive growing of cereal. Ear fusarirose has caused significant yield losses of winter wheat. During the 1990s, wheat producers in regions affected by

*Fusarium* head blight have suffered cumulative losses of \$1.3 billion, according to analysis by Johnson et al. (2003). In Russian total yield losses of winter wheat from *Fusarium* head blight reached to 44-88% (Tsumakov and Zaharova, 1990). Contamination of mycotoxins, what are produced by consumption *Fusarium* species in cereal grains, is a hazardous factor for using of these products in human foods and animal feeds. Species predominantly found associated with *Fusarium* head blight in Europe are *F. graminearum*, *F. culmorum*, *F. avenaceum*, *F. sporotrichiella* (Bottalico, 1998). *F. culmorum* predominates in grain crop in the Netherlands, Germany and northern Europe (Mielke, 1988, Parry et al. 1995). These species are the most widespread as seed-borne pathogens identified in winter wheat in Latvia, too (Treikale and Pugacheva, 2002).

Climate appears to be a major limiting factor in the distribution of many species of *Fusarium* (Backhouse et al. 2002). More observers have noted relationships between high humidity during the flowering and fusarium head blight occurrence (Bushnell et al. 2003). In Latvia, climatic factors are influential in spreading of fusarial head blight of cereal caused by *Fusarium* species. Control of ear fusarioses in wheat is a complex problem. The most significant factor affecting the incidence of fusarial head blight in winter wheat in Latvia is heightened temperature at the time of anthesis of wheat. Usually, average temperature during the flowering of winter wheat in the third ten-days period of June in Latvia is not higher than 17°C but air humidity is high in a result of frequent rain. Using of fungicides in this period is limited by wet weather conditions, fusarium control is depending on efficacy of fungicides and riskiness of their residues uptake into the yield. Only a few very effective active ingredients are available for control of fusarial head blight, from them tebuconazole showed very good efficacy against *Fusarium* spp. development on ears of wheat (Mielke et al. 1996; Mesterhazy et al. 2001). The tebuconazole treatment increased plot yields by 21% and significantly decreased contamination of mycotoxins in grains of wheat (Mauler-Machnik et al. 1994). Tvaruzek (2001) obtained good control of ear fusariosis after using of tebuconazole and significant reduce of mycotoxins concentration in harvested grains. In Latvia control of *Fusarium* head blight with fungicides which contain tebuconazole in intensive growing of wheat are apply in the last few years.

In this study effectiveness of new fungicides used at flowering of winter wheat in the control of *Fusarium* head blight and leaf diseases were evaluated.

## MATERIAL AND METHODS

Field trials in 2003-2004 were carried out in sowing of winter wheat 'Kobra' in accordance with EPPO guidelines. Trials carried out in four replicates using randomized block design, with plot size of 30 m<sup>2</sup>. In the field trial of 2003 Prosaro 250 EC (tebuconazole 125 G, prothioconazole 125 G L<sup>-1</sup>) and Input 460 EC (spiroxamine 300 G, prothioconazole 160 G L<sup>-1</sup>) have been tested by artificial infection with *F. culmorum*, *F. avenaceum* var. *herbarum*, *F. gibbosum*, a plot size 12 m<sup>2</sup>. Plots were inoculated at flowering stage with causative agents isolated from infected ears of

winter wheat and propagated on PDA. Plots were inoculated by spray with knapsack sprayer in favourable weather conditions for infection: high air temperature (+20°C) and air humidity after rain (99%). Concentration of conidia by inoculation was  $10^6 \text{ ml}^{-1}$ , volume ratio: 1:1:1. Application of fungicides has been 6 days later. Weather conditions during the flowering of winter wheat and in beginning of kernel formation were favourable for infestation of *Fusarium* head blight.

The trial in 2004 was carried out in conditions of natural infection. Orius 250 EW (tebuconazole 250 G L<sup>-1</sup>) in dose 1.0 L ha<sup>-1</sup> and Prosaro 250 EC in doses 1.0 and 0.75 L ha<sup>-1</sup> have been tested by application at T3 compared with Folicur 250 EW (tebuconazole 250 G L<sup>-1</sup>), Falcon 460 EC (tebuconazole 167 G, triadimenol 43 G, spiroxamine 250 G L<sup>-1</sup>) and Juventus 60 (metconazole 60 G L<sup>-1</sup>) used at the same time. In the trial application of fungicide Sfera 267.5 EC containing cyproconazole (80 G L<sup>-1</sup>) and trifloxystrobin (187.5 G L<sup>-1</sup>) at T1 was carried out. In 2004 low air temperature at flowering of wheat was not favourable for infection of ears.

*Fusarium* head blight was assessed on 100 randomly selected ears in each plot. Observations on leaf diseases were assessed as percentage of all green leaves by the each individual disease. Diseases incidence and severity were assessed with 7 days interval at 25 randomly selected plants in each plot.

Yield was harvested with grain harvester of small cut. The grain yield was corrected to 100% purity and to standard grain moisture 15% content. TGW was measured. Experimental data were subjected to analysis of variance, treatment means were separated at the 95% probability level using F-test with program of variance analysis.

## RESULTS

### Control of leaf diseases

In conditions of 2003 in winter wheat moderate attack of *Erysiphe graminis* was observed. Before fungicides application the severity of the disease was 2.32%. Development of powdery mildew in untreated plots was reached to 12.2% at the GS 72 (Fig. 1).

Prosaro in doses 0.75 L and 1.0 L ha<sup>-1</sup> and Input in dose 1.0 L ha<sup>-1</sup> were effective to control powdery mildew. Both fungicides significantly retarded the development of *E. graminis* on leaves of winter wheat. In milky ripeness stage severity of the disease was 0.4-0.6%. Application of Prosaro and Input gave good control of *E. graminis* in winter wheat during the three weeks. The effectiveness of new fungicides was on the level of azole products used in the trial at the same time: Folicur, Falcon and Juventus (Table 1).

In conditions of 2003 epiphytotic development of tan spot (*Drechslera tritici-repentis*) was marked in winter wheat. Before application of fungicides, at the GS 65, in the trial 100% infestation of *D. tritici-repentis* by severity to 10.5% was marked. Tan spot in control-untreated during the following two weeks was developed to 25.1%. The severity of tan spot on the top leaves of winter wheat at GS 75 was 80.6% (Fig. 2).

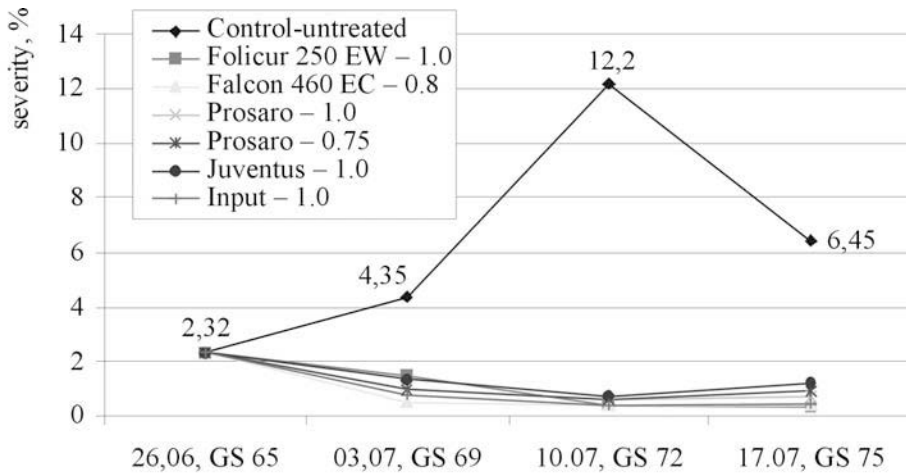


Fig. 1. Development of *Erysiphe graminis* in the winter wheat (trial 2003).

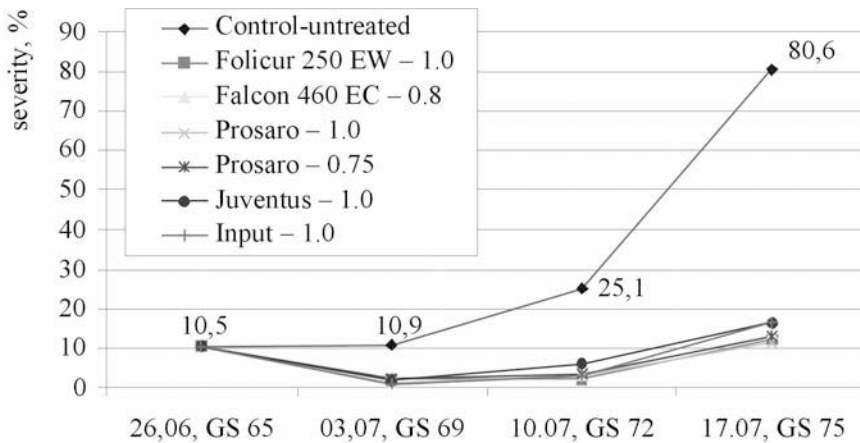


Fig. 2. Development of *Drechslera tritici-repentis* in the winter wheat (trial 2003).

Application of fungicides significantly decreased the development of tan spot. One week after application efficacy of Prosaro in doses 0.75 and 1.0 L ha<sup>-1</sup> in the control of tan spot was about 80%. Prosaro was effective in the control of tan spot during the two weeks after application: about 87% (Table 2).

Table 1

Efficacy of the fungicides in the control of *Erysiphe graminis* on winter wheat (2003).

Previous: winter wheat Sowing: 29.09.2002 Harvesting: 07.08.2003		Soil: soddy-calcareous, pH 7.0 Organic matter content: 2.1% Fertilizing: N <sub>12</sub> P <sub>52</sub> K <sub>60</sub> + N <sub>90</sub>		Application: 26.06.2003, GS 65 Equipment: knapsack sprayer	
Treatments	Dose, L ha <sup>-1</sup>	10.07, GS 72		17.07, GS 75	
		Severity, %	Effect, %	Severity, %	Effect, %
Control	untreated	12.20	-	6.45	-
Folicur 250	1.0	0.39	96.7	0.33	94.9
Falcon 460	0.8	0.39	96.7	0.38	94.1
Prosaro	1.0	0.60	95.1	0.70	89.1
Prosaro	0.75	0.60	95.1	0.88	86.4
Juventus	1.0	0.70	94.3	1.20	81.4
Input	1.0	0.40	96.7	0.45	93.0
LSD <sub>05</sub>	-	8.37	-	2.85	-

Table 2

Efficacy of the fungicides in the control of *Drechslera tritici repentis* in winter wheat (2003).

Previous: winter wheat Sowing: 29.09.2002 Harvesting: 07.08.2003		Soil: soddy-calcareous, pH 7.0 Organic matter content: 2.1% Fertilizing: N <sub>12</sub> P <sub>52</sub> K <sub>60</sub> + N <sub>90</sub>		Application: 26.06.2003, GS 65	
Treatments	Dose, L ha <sup>-1</sup>	10.07, GS 72		17.07, GS 75	
		Severity, %	Effect, %	Severity, %	Effect, %
Control	untreated	25.12	-	80.60	-
Folicur 250	1.0	2.05	91.8	12.30	84.7
Falcon 460	0.8	2.97	88.2	13.40	83.4
Prosaro	1.0	3.17	87.4	11.09	86.2
Prosaro	0.75	3.45	86.3	13.10	83.7
Juventus	1.0	6.15	75.5	16.50	79.5
Input	1.0	3.07	87.8	16.50	79.5
LSD <sub>05</sub>	-	3.33	-	10.25	-

The fungicide Input in dose 1.0 L ha<sup>-1</sup> gave the same effect in the control of tan spot as Prosaro. One week after application Input gave very good effect (91.5%) in the control of tan spot (Table 2).

During the trial 2004 was observed slight level of attack with powdery mildew, severe infection by *Septoria tritici* and severe attack of tan spot (Fig. 3). Application of Sfera at the beginning of infestation of leaf diseases at T1 (GS 33) in the trial (including control) in dose 0.8 L ha<sup>-1</sup> was effective to delay of development of diseases during one month after spray. At T3 (GS 65) before application of fungicides to control of *Fusarium* head blight in the trial was observed slight infection of the leaf diseases (Fig. 3).

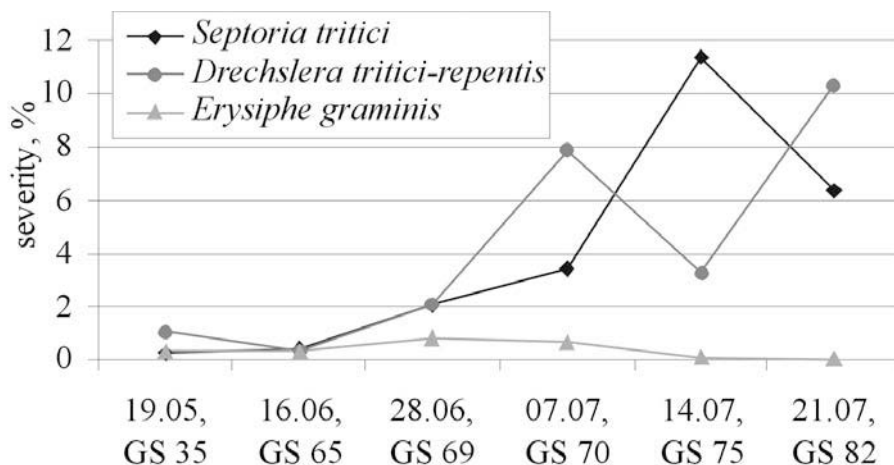


Fig. 3. Dynamics of leaf diseases development in winter wheat in the trial 2004.

Table 3

Effectiveness of fungicides in the control of *Septoria tritici* on winter wheat.

Previous: winter wheat Sowing: 10.09.2003 Harvesting: 18.08.2004		Soil: soddy-calcareous, pH 7.0; Org. content: 2.0% Fertilizing: N <sub>8</sub> P <sub>40</sub> K <sub>40</sub> + N <sub>70</sub> + N <sub>70</sub> + N <sub>35</sub> Sfera 267.5 EC 0.8 L ha <sup>-1</sup>		Application: 16.06.2004, GS 65	
Treatments	Dose, L ha <sup>-1</sup>	07.07, GS 70		14.07, GS 75	
		Severity, %	Effect, %	Severity, %	Effect, %
Control	untreated	3.45	-	11.35	-
Folicur 250	1.0	1.10	68.1	2.08	81.7
Prosaro	1.0	0.50	85.5	1.55	86.3
Prosaro	0.75	1.23	64.5	2.12	81.3
Falcon 460	0.8	0.78	77.5	2.28	79.9
Juventus 60	1.0	1.25	63.8	2.42	78.7
Orius 250	1.0	0.95	72.5	1.88	83.4
LSD <sub>95</sub>	-	0.68	-	2.62	-

The efficacy of Prosaro in dose 1.0 L ha<sup>-1</sup> in the control of *S. tritici* 10 days after application was 80% and one month after application 86.3% (Table 3). Application of Orius in dose 1.0 L ha<sup>-1</sup> gave the same effect as Folicur.

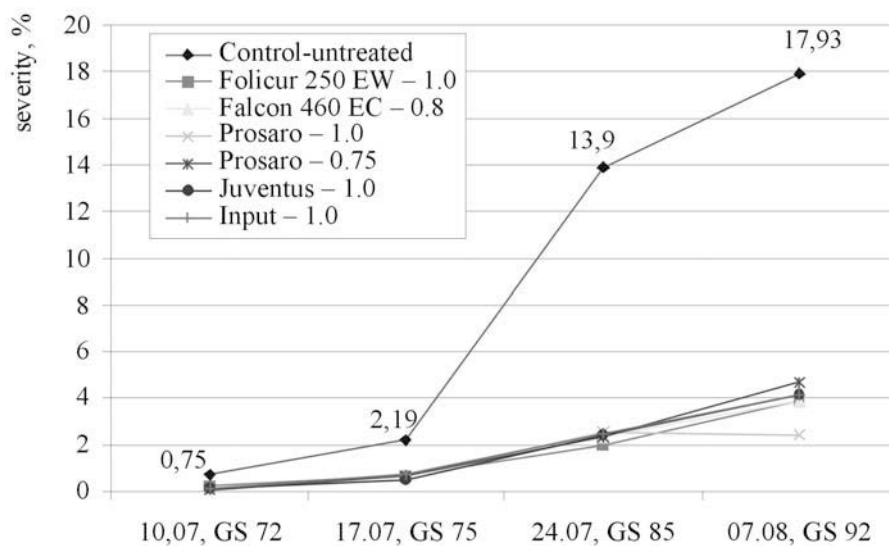


Fig. 4. Development of *Fusarium* head blight on winter wheat by artificial infection (trial 2003).

Table 4

Effectiveness of fungicides in the control of *Fusarium* head blight in winter wheat (2003).

Treatments	Dose, L·ha <sup>-1</sup>	10.07, GS 72		07.08, GS 92	
		Severity, %	Effect, %	Severity, %	Effect, %
Control	untreated	2.19	-	17.93	-
Folicur 250	1.0	0.63	71.2	3.85	78.5
Falcon 460	0.8	0.56	74.4	3.90	78.2
Prosaro	1.0	0.65	70.3	2.45	86.3
Prosaro	0.75	0.65	70.3	4.67	74.0
Juventus	1.0	0.50	77.2	4.15	76.9
Input	1.0	0.74	66.7	4.17	76.7
LSD <sub>95</sub>	-	0.50	-	3.45	-

In the control of leaf blotch by new fungicides and standard products: Falcon, Folicur, and Juventus no significant differences were found. In conditions of 2004 all fungicides during the month after application were effective in the control of tan spot and powdery mildew. Lower dosage of Prosaro showed slightly lower effect against leaf diseases.

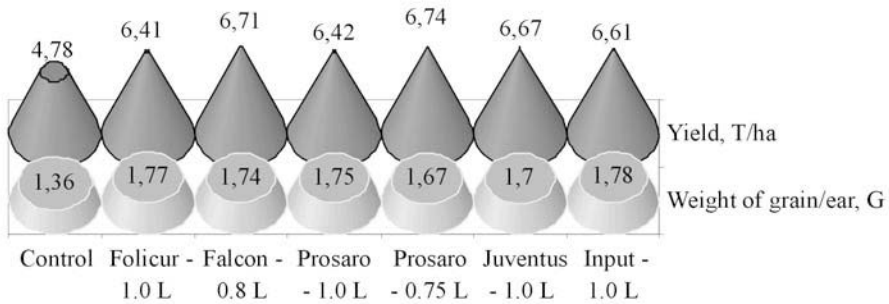


Fig. 5. The influence of application of the fungicides on yield of winter wheat (trial 2003).

### Control of *Fusarium* head blight

In the trial of 2003 by artificial inoculation of winter wheat with *Fusarium* spp. at high air temperature and air humidity during the flowering period and in period of kernel formation (favours disease development) the disease spreading increased from 7.5% to 88.0% by severity from 0.75% to 13.9% in plots where fungicides were not used (Fig. 4). At the same time natural infection was developed from 0.5% to 8.5% (near field).

By high level of development of the disease the application of Prosaro gave good control of *Fusarium* spp. on ears of winter wheat. Efficacy of the fungicide in dose 1.0 L · ha<sup>-1</sup> in the control of *Fusarium* head blight was 86.3%. In lower dose Prosaro was less effective (74%) (Table 4).

The efficacy of Input in the control of *Fusarium* head blight was 76.7%. Efficacy of Prosaro in control of the disease about 80% was on the same level as Falcon in dose 0.8 L ha<sup>-1</sup>, Folicur in dose 1.0 L · ha<sup>-1</sup> and Juventus in dose 1.0 L · ha<sup>-1</sup> used at the same time.

In conditions of 2003 leaf diseases and *Fusarium* head blight have significant influence on yield formation of winter wheat. Grain yield in control-untreated was 4.78 T ha<sup>-1</sup> (Fig. 5). By counting of number of grain and their weight per ear were found the significant differences between control-untreated and treatments with fungicides application. By application of Folicur and Input in dose 1.0 L · ha<sup>-1</sup> was formed the most laden kernel: weight of grain per ear was on 31.0% higher than in untreated (Table 5).



Table 5

Effectiveness of fungicides in the control of *Fusarium* spp. on ear of winter wheat (2003).

Treatments	Dose, L·ha <sup>-1</sup>	Number of grains per ear		Weight of grain per ear	
		Number	% to control	G	% to control
Control	untreated	34.97	100.0	1.360	100.0
Folicur 250	1.0	40.23	115.0	1.767	129.9
Falcon 460	0.8	39.71	113.6	1.742	128.1
Prosaro	1.0	39.21	112.1	1.752	128.8
Prosaro	0.75	38.77	110.9	1.667	122.6
Juventus	1.0	38.55	110.2	1.695	124.6
Input	1.0	40.21	115.0	1.782	131.0
LSD <sub>95</sub>	-	2.70	-	0.109	-

Table 6

Effectiveness of fungicides in the control of *Fusarium* head blight of winter wheat (2004).

Treatments	Dose, L·ha <sup>-1</sup>	<i>Fusarium</i> head blight		Yield	
		Severity, %	Biological effect, %	T ha <sup>-1</sup>	Increase to control, %
Control	untreated	4.51		8.71	100.0
Folicur 250	1.0	1.13	75.1	9.70	111.4
Prosaro	1.0	0.66	85.5	9.42	108.2
Prosaro	0.75	1.27	72.0	9.60	110.2
Falcon 460	0.8	1.75	61.3	9.39	107.8
Juventus 60	1.0	1.41	68.7	9.46	108.6
Orius 250	1.0	0.93	79.4	9.52	109.3
LSD <sub>95</sub>		0.60		0.45	

The application of the fungicides in conditions of 2003 gave significant influence on yield of winter wheat in comparison with untreated. The increase of yield in average was higher than 30%. TGW in all treatments was significantly increased compared with untreated.

*Fusarium* head blight in conditions of 2004 was observed on 78.8% ears, severity level was not high: 4.5% in untreated. All fungicides used at the flowering of winter wheat gave good control of the disease. Prosaro in dose 1.0 L · ha<sup>-1</sup> gave better control of the disease: efficacy 85.5% (Table 6).

By application of Prosaro in dose 0.75 L · ha<sup>-1</sup> the effectiveness against infestation of *Fusarium* spp. on ears of winter wheat was lower, but in the treatment the disease severity was significantly delayed. The effectiveness of Orius against *Fusarium* spp. infection on ears of winter wheat was slightly higher than Folicur.

In conditions of 2004 the total grain yield of winter wheat in the trial was very high: 8.71 T ha<sup>-1</sup> in untreated. The grain yield was significantly increased in all treatments in comparison with untreated (Table 6). In all treatments with application of the fungicides TGW was significantly higher compared with untreated.

## DISCUSSION

The investigations on effectiveness of fungicides in the control of *Fusarium* head blight in Latvia showed possibility and necessity of application of products which contain tebuconazole. Application of fungicides at T3 of winter wheat gave good control of the disease spread and development on ears. Most effective control in both trials showed Prosaro.

Assessment of number of grain/ear and their weight in condition of artificial inoculation in the trial 2003 showed on significant influence of *Fusarium* spp. infection of ear on forming of yield of winter wheat. Most important is the distribution of infection into the grain, which led to a significant decrease of germination of seeds and to development of root rot of seedlings of wheat after sowing. In our investigations (Treikale and Guzeva, 1996) from key pathogens identified as causative agents of root rot in winter wheat 77% belong to *Fusarium* spp., in spring wheat from 63 to 87% of all causative agents were *Fusarium* spp.: *F. culmorum*, *F. gibbosum*, *F. sambucinum*, *F. avenaceum* v. *herbarum*, *F. oxysporum*.

Effective control of *Fusarium* head blight can be obtained through application of fungicides with different active substance in two times: at T1 and at T3. In the trial 2004 in intensive growing of winter wheat high efficacy of application of fungicides containing cyproconazole and trifloxystrobin at T1 to control of leaf diseases (*Septoria tritici*, *Erysiphe graminis*, *Drechslera tritici-repentis*) was achieved, the application of fungicides containing tebuconazole at T3 gave significant influence on yield of winter wheat and TGW. Intensification of farming where winter wheat will be grown by intensive technologies in accordance with agrotechnical requirements and by integrated crop protection will make it possible to significantly decrease ear fusarioses and greatly reduce the mycotoxin content in the grains.

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## **Zwalczanie fuzariozy kłosów pszenicy ozimej za pomocą sztucznego i naturalnego zakażenia przy zastosowaniu nowych fungicydów**

### Streszczenie

Na Łotwie czynniki klimatyczne mają wpływ na szerzenie się fuzariozy zbóż wywołanej gatunkami *Fusarium*. Najważniejszym czynnikiem wpływającym na występowanie choroby w pszenicy ozimej jest podwyższona temperatura w czasie kwitnienia pszenicy. W latach 2003-2004 przeprowadzono badania polowe zwalczania choroby w pszenicy ozimej za pomocą nowych fungicydów stosowanych w różnej ilości poprzez naturalne zakażenie i sztuczną inokulację. Trzy gatunki czynników

sprawczych: *Fusarium avenaceum* var. *herbarum*, *F. gibbosum*, *F. culmorum*, zebrano z zakażonych ziaren pszenicy i użyto do inokulacji poletek doświadczalnych przy stężeniu  $10^6$  konidiów na  $\text{ml}^{-1}$  (1:1:1) w fazie pełnego kwitnienia. Uzyskano skuteczne zwalczanie choroby poprzez zastosowanie nowych fungicydów z różnymi aktywnym składnikami: Prosaro 250 EC (tebukonazol 125 G, propikonazol 125 G  $\text{L}^{-1}$ ), Input 460 EC (spiroksamina 300 G, propikonazol 160 G  $\text{L}^{-1}$ ). W warunkach sztucznego zakażenia poprzez ostry atak *Fusarium* spp., zastosowanie fungicydów zawierających tebukonazol w okresie czasu T3 dało znaczny wpływ na plon pszenicy ozimej poprzez zwiększenie pulchności ziaren. W badaniu uzyskano również wysoką skuteczność fungicydów w zwalczaniu zakażenia liści wywołanym przez *Erysiphe graminis* i *Drechslera tritici-repentis*.

Zastosowanie fungicydów zawierających cyprokronazol i trifloksystrobinę w okresie czasu T1 w badaniu w 2004 roku dało dobre zwalczanie *Septoria tritici*, *E. graminis* i *D. tritici-repentis*.