Effectiveness of Fungicides against Head Blight of Wheat caused by *Fusarium culmorum*

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Abstract

TAKISH Y., VAVERKA S. (1999): **Effectiveness of fungicides against head blight of wheat caused by** *Fusarium culmorum*. Pl. Protect. Sci., **35**: 63–66.

Fungicides were tested in 1996 and 1997 for their efficacy to control *Fusarium culmorum* after inoculation of winter wheat in the early flowering stage. The best results were achieved with metconazole and a mixture of tebuconazole with triadimefon or triadimenol. Good results were achieved with epoxiconazole, cyproconazole, flusilazol and bromuconazole.

Key words: *Fusarium culmorum*; head blight; winter wheat; fungicides

Head blight caused by *Fusarium* species is a common and destructive disease of wheat in humid and semi-humid growing areas of the world (MOSCHINI & FORTUGNO 1996). *Fusarium graminearum* Schwabe, *F. culmorum* (W. G. Smith) Sacc., *F. avenaceum* (Corda ex Fr) Sacc and *Microdochium nivale* Fries (syn. *F. nivale*) are most frequently reported as causal agents of head blight (PARRY *et al.* 1995). Anthesis appears to be a period of increased susceptibility of wheat ears to *Fusarium* infection. Infection starts from one or more florets in the spike. The disease can spread in a wide range of temperatures (15–30 °C), with the optimum about 25 °C, and is associated with years of above average rainfalls (SUTTON 1982). *Fusarium* head blight causes significant yield losses. In extreme cases it can reduce yields by as much as 70% (MIHUTA & FORSTER 1989). SNIJDERS and PERKOWSKI (1990) demonstrated that losses of yield result from a decreased number and weight of grains in the spike.

Fungicidal control of *Fusarium* head blight appears possible, but has to be further tested and discussed. In a review article, PARRY *et al.* (1995) express the view that a number of factors is responsible for the wide variation in the results of blight control. The time of application may be one of the important factors. The period for correct application may be too short (at anthesis). Seed treatment is effective against seed borne infection, but has little effect against infection of ears.

However, there are some reports in the literature describing successful fungicidal control of the disease. The best control of the disease caused by *F. graminearum* was achieved by applying fungicides at the beginning of flowering (BALAŽ 1989). HUTCHEON and JORDAN (1992) recommended to combine wet seed treatment and a later application of fungicides on ears and leaves. In greenhouse trials they got positive results with triadimenol and tebuconazole. It is always preferable to use a combination of active ingredients (DE WAARD 1996). By following these principles, application of tebuconazole resulted in a significant decrease of the infection of ears and mycotoxins content, and an increase in quality of the seed (OBST *et al.* 1992). Similarly successful were a mixture of tebuconazole with triadimefon (BOYACIOGLU *et al.* 1992), propiconazole (MCMULLEN *et al.* 1997) and hexaconazole (WALLER *et al.* 1990). Some other fungicides and their combinations were recommended by MAULER and SUTY (1997).

From the results available in the literature it was clear that the efficacy of fungicides should be tested on a number of varieties, and in a series of investigations performed over several years to select fungicides with adequate effect and long effectiveness. Natural infection is always uncertain, and often the level of infection is insufficient for significant differences between treated and control plots. As inoculation gives a more reliable infection we used this method in field trials.

MATERIALS AND METHODS

The investigations began in 1996 with the varieties of winter wheat Siria and Sparta. The experiment was seeded by hand in three replications; the seeds were distributed in circles (20 kernels per circle at a diameter of 30 cm).

One needed circle was one replication. *Fusarium culmorum* was chosen for inoculation because it is the main species causing head blight in the Czech Republic. The inoculum was applied by spraying at a final concentration of 1×10^6 spores per ml. Plots were inoculated at DC 61 (beginning of anthesis) (TOTTMAN & BROAD 1987). The fungicides were applied 24 h after inoculation; their rates are listed in Tables 1 and 2. The control was an inoculated but untreated variant.

After harvest we assessed the average grain weight per ear of 30 randomly selected ears of each treated and the control variant, and calculated the percentage of increase of ear productivity caused by the applied fungicides. The results were analysed using standard statistical methods.

In 1997 we used the variety Hana of winter wheat for the trials. Seeding and inoculation by *F. culmorum* at DC 61 were performed in the same way as in 1996, but the trial was treated with fungicides 2 days after inoculation (Table 5). Visual symptoms of ear infection were evaluated 14 and 28 days after inoculation according to James's scale (JAMES 1971):

degree of evaluation:	0	1	2	3	4	5
% infection of ear:	0	10	25	50	75	100

The results were expressed by the formula of Area Under the Disease Progress Curve (AUDPC; SHANNER & FINNEY 1977). The effect of treatments on yield was assessed as in 1996.

Fungicides: Alert (flusilazol 125 g/l, carbendazim 250 g/l); Alto 320 SC (cyproconazole 320 g/l); Alto Combi 420 SC (cyproconazole 120 g/l, carbendazim 300 g/l); Archer 425 EC (fenpropimorph 300 g/l, propiconazole 125 g/l); Caramba (metconazole 60 g/l); Cerelux (flusilazol 160 g/l, tridemorph 350 g/l); Folicur BT 225 EC (tebuconazole 125 g/l, triadimefon 100 g/l); Folicur Plus 375 EC (tebuconazole 250 g/l, triadimenol 125 g/l); Granit 20 SC (bromuconazole 200 g/l); Opus (epoxiconazole 125 g/l); Opus Team (epoxiconazole 84 g/l, fenpropimorph 240 g/l); Sportak 45 EC (prochloraz 450 g/l); Tango (epoxiconazole 125 g/l, tridemorph 375 g/l); Tilt 250 EC (propiconazole 250 g/l).

RESULTS AND DISCUSSION

In 1996 a significantly increased grain weight was achieved on the varieties Siria and Sparta by application of fungicides in comparison with the untreated control variant (Tables 1 and 2). The statistical data show highly significant differences between the fungicides (Tables 3 and 4). The best results were obtained by application of Caramba at the rate 1.5 l/ha, but it still performed well at the reduced rate of 1 l/ha. Next best was Folicur Plus 375 EC. Significant results were achieved also by Opus and Tango. Alto Combi 420 SC was better than Tilt 250 EC or Alert. There were no differences between Siria and Sparta in the reaction to infection (Tables 1–3).

Table 1. Evaluation of effectiveness of fungicides against Fusarium head blight (variety Siria in 1996)

Fungicide	Rate [l/ha]	Grain weight of ear [g]	Relative yield, with control = 100
Alert	1.0	0.98	148.5
Alto Combi 420 SC	0.5	1.28	193.9
Caramba	1.0	1.17	177.3
Caramba	1.5	1.62	245.4
Folicur Plus 375 EC	0.75	1.50	227.3
Opus	1.0	1.36	206.1
Tango	1.0	1.39	210.6
Tilt 250 EC	0.5	0.99	150.0
Control	–	0.66	100.0

Table 2. Evaluation of effectiveness of fungicides against Fusarium head blight (variety Sparta in 1996)

Fungicide	Rate [l/ha]	Grain weight of ear [g]	Relative yield, with control = 100
Alert	1.0	0.92	143.8
Alto Combi 420 SC	0.5	1.27	198.4
Caramba	1.0	1.12	175.0
Caramba	1.5	1.51	236.0
Folicur Plus 375 EC	0.75	1.46	228.1
Opus	1.0	1.41	220.0
Tango	1.0	1.38	215.6
Tilt 250 EC	0.5	1.07	167.2
Control	–	0.64	100.0

In 1997 the ear infection by *Fusarium* was significantly reduced by most of the fungicides as shown by a comparison of the AUDPC of treated variants with that of the control (Table 5). The fungicides Caramba (rate 1.2 l/ha) and Folicur BT 225 EC decreased the rate of development of infection in comparison with the control variant and other treated variants. The fungicides Alert, Caramba (rate 1.2 and 1.5 l/ha), Folicur BT 225 CE and Opus Team were able to stop the development of infection till the symptoms were evaluated. Significant results were obtained with Archer 425 EC, Granit 20 SC, Sportak 45 EC and Tilt 250 EC. Most efficacious were Caramba, Folicur BT 225 EC, Tango, Opus, Alto Combi 420 SC, Opus Team and Alert, in that order (Table 5). The lowest effectiveness was reached with Cerelux.

At the beginning of flowering, when the ears are more susceptible to infection, the climatic conditions were not suitable for the spread of infection. This helped the fungicides to fully prove their effectiveness. Therefore, the values of ear infection at the time of evaluation were significant for almost all tested fungicides.

Table 3. Analysis of variance – HSD 1996

Source of variation	SS	df	MS	*F*–ratio	Significance
Fungicides	0.6656938	7	0.0950991	51.035	0.0000***
Cultivars	0.0014063	1	0.0014063	0.755	0.4228
Standard error	0.0130437	7	0.0018634		
Total	0.6801438	15			

Table 4. Differences between used fungicides (1996) – Tuckey HSD

fungicide	Count	Average	Homogeneous groups
1. Alert	2	0.950	x
8. Tilt 250 EC	2	1.030	xx
3. Caramba 1	2	1.145	xx
2. Alto Combi 420 SC	2	1.275	xx
6. Opus	2	1.385	xx
7. Tango	2	1.385	xx
5. Folicur Plus 375 EC	2	1.480	xx
4. Caramba 1.5	2	1.565	x

After the early milk growth stage, especially at the beginning of July 1997, it rained several times, resulting in high relative humidity and with temperatures about 19 °C. These conditions were again favourable for the spread of infection by *Fusarium* and for infection by other fungi. This explains why the percentage of increase in the weight of grain per ear in the variants treated by fungicides was so high compared with the untreated control variant. The control variant suffered by infection from the beginning and when these climatic conditions came it was still more susceptible to infection by other agents, and thus suffered higher yield losses.

From the results the fungicides can be grouped according to their efficacy. The best are those with the active ingredient metconazole or tebuconazole. Our investigations confirmed the good efficacy of formulations with

Table 5. Evaluation of effectiveness of fungicides against Fusarium head blight (variety Hana in 1997)

Fungicide	Rate [l/ha]	% ear damage after inoculation		AUDPC	Grain weight of ear [g]	Relative yield, with control = 100
		14 days	28 days			
Alert	1	10	10	140	1.15	188.5
Alto 320 SC	0.25	0 –10	50	385	1.1	180.3
Alto Combi 420 SC	0.5	0–10	50	385	1.19	195.1
Archer 425 EC	1	10–25	25	297.5	1.07	175.4
Caramba	1	0	25	175	1.16	190.2
Caramba	1.2	0	10	70	1.29	211.5
Caramba	1.5	10	10	140	1.48	242.6
Cerelux	1	10	50	420	0.8	131.1
Folicur BT 225 EC	1	0	10	70	1.38	226.2
Granit 20 SC	0.8	10	50	420	1.02	167.2
Opus	0.6	10	25	245	1.26	206.5
Opus team	1	10	10	140	1.18	193.4
Sportak 45 EC	1	10	50	420	1.01	165.6
Tango	0.8	0–10	25	210	1.3	213.1
Tilt 250 EC	0.5	10–25	50	472.5	0.99	162.3
Control	–	25	75	700	0.61	100.0

the active ingredient epoxiconazole. Fungicides with cyproconazole were better than fungicides with propiconazole, bromuconazole, prochloraz or flusilazol.

To sum up, application of effective fungicides at flowering decidedly decreased the infection of winter wheat by *Fusarium* head blight and increased yield. Treatment with reduced rates of some fungicides also gave significant results.

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Received for publication May 5, 1999
Accepted for publication May 13, 1999

Souhrn

TAKISH Y., VAVERKA S. (1999): **Účinost fungicidů proti fuzariózám klasů pšenice způsobovaných** *Fusarium culmorum*. Pl. Protect. Sci., **35**: 63–66.

V letech 1996 a 1997 byla studována účinnost vybraných fungicidů proti fuzariózám klasu na pšenici ozimé při umělé infekci houbou *Fusarium culmorum* v době kvetení. Nejlepší účinky byly zjištěny po aplikaci fungicidů na bázi metconazolu a kombinace tebuconazol s tridimefonem nebo tebuconazol s triadimenolem. Po aplikaci účinných látek epoxiconazol, cyproconazol, flusilazol a bromuconazol byly zjištěny dobré účinky.

Klíčová slova: *Fusarium culmorum*; fusariosy klasu; pšenice ozimá; fungicidy

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