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In vitro sensitivity of *Fusarium graminearum*, *F. avenaceum* and *F. verticillioides* to carbendazim, tebuconazole, flutriafol, metconazole and prochloraz

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SUMMARY

Growth of 13 *F. graminearum* isolates, 6 *F. avenaceum* isolates and 6 *F. verticillioides* isolates was analysed on potato-dextrose agar amended with 0.1, 0.33, 1, 3.3 and 10 mg l^{-1} of carbendazim, tebuconazole, flutriafol, metconazole, and prochloraz. Average concentration which reduced mycelial growth by 50% comparing it to control (EC_{50}) was calculated for each isolate. Among fungicides tested, prochloraz was shown to be the most effective in growth inhibition of all three species, while flutirafol was proven to be the least effective. Metocnazole was more efficient in comparison with carbendazim and tebuconazole. EC_{50} values of all isolates on prochloraz were lower than 0.1 mg l^{-1}, while on flutirafol they ranged between 1.66 and 8.51 mg l^{-1} for 18 isolates, or were higher than 10 mg l^{-1} for 7 isolates. EC_{50} values on carbendazim were 0.39-1.41 mg l^{-1} for *F. graminearum* isolates, 0.91-1.35 mg l^{-1} for *F. avenaceum*, and 0.47-0.6 mg l^{-1} for *F. verticillioides*. EC_{50} values on tebuconazole were 0.85-2.57 mg l^{-1} for *F. graminearum*, 0.85-1.58 mg l^{-1} for *F. avenaceum* and 0.22-0.85 mg l^{-1} for *F. verticillioides*, while on metconazole EC_{50} values ranged between less than 0.1 mg l^{-1} to 1.66, 0.56, and 0.17 mg l^{-1} for *F. graminearum*, *F. avenaceum* and *F. verticillioides*, respectively. Average growth inhibitions of different *Fusarium* species and all *Fusarium* isolates together on different concentrations of fungicides tested were significantly different. Significant differences in growth were not determined among isolates of the same species on neither one of fungicides tested, indicating that no decreased sensitivity to the fungicides exists among isolates included in the study.

Keywords: *Fusarium*; Carbendazim; Tebuconazole; Flutriafol; Metconazole; Prochloraz

INTRODUCTION

Fusarium head blight (FHB) is one of the most important diseases of wheat worldwide (McMullen et al., 1997). FHB epidemics are common in Croatia, as most of the wheat cultivars grown are susceptible to FHB, and wheat is frequently followed by maize in crop rotation. Continental climate with frequent spring rains further contribute to FHB epidemics, which are particularly severe in certain years. In such conditions, the use of fungicides is still one of the main strategies in FHB management in Croatia. The use of fungicides in control of FHB has become more intensively investigated during the last two decades, since studies have shown that chemical control of *Fusarium* diseases of wheat can contribute to the lower contamination of grain with mycotoxins, especially deoxynivalenol and zearalenone (Ellner, 1997; Mesterházy and Bartók, 1997; Matthies and Buchenauer, 2000; Pirgozliev et al., 2002; Menniti et al., 2003).

From the 70s of the 20th century, carbendazim was commonly used in management of FHB. This benzimidazole fungicide was proven to be effective in laboratory studies and in practice, and it remained as one of the standards in control of wheat diseases caused by *Fusarium* (Delp, 1987). However, during the 80ies, demethylation inhibitors (DMI fungicides) have become the most commonly used fungicides in agriculture. DMI fungicides were shown to be extremely broad-spectrum chemicals, similar like benzimidazoles, and were proven to be effective in FHB control. Today, DMI fungicides still represent the largest group of fungicidal compounds on the market. In products registered to be used on cereals today, they are often combined with strobilurins. Beside the use of carbendazim, tebuconazole, flutriafol, prochloraz and metconazole as foliar sprays on wheat and barley, all of these fungicides are also used in seed treatments, for control of seed-borne *Fusarium* and Fusarium seedling blight.

According to several studies, the most common *Fusarium* species on wheat in Croatia are *F. graminearum*, *F. avenaceum* and *F. verticillioides* (Ćosić and Vrandečić, 2003; Ćosić et al., 2004). Among these species, *F. graminearum* is the main causal agent of FHB (McMullen et al., 1997; Lević, 2008). *F. avenaceum* is regarded as a saprotroph on cereals by some authors (Summerell et al., 2003), but several studies confirmed the pathogenicity of this species on wheat (Jenkinson and Parry, 1994; Kang et al., 2005). *F. verticillioides* is an important pathogen of maize, but it does not cause FHB (Leslie and Summerell, 2006). Besides differing in their pathogenicity on wheat, *F. graminearum*, *F. avenaceum* and *F. verticillioides* are phylogenetically distinct, and have different life cycles and toxigenic profile (Leslie and Summerell, 2006; Lević, 2008).

This laboratory study was conducted to evaluate the sensitivity of *F. graminearum*, *F. avenaceum* and *F. verticillioides* to carbendazim, tebuconazole, flutriafol, metconazole, and prochloraz, by mycelial growth inhibition method (Wong and Wilcox, 2002; Wong and Midland, 2007).

MATERIAL AND METHODS

Isolation and identification of fungal strains

Fusarium strains used in the study were isolated from wheat grain collected in 2006 from the fields where epidemics of FHB were recorded. Grain was not surface-sterilised and was incubated on moist blotter for 7 to 10 days on 22°C and 12/12 h photoperiod. Colonies developed on grain were examined with stereomicroscope and microscope. Single-spore isolates were obtained from sporulating *Fusarium* colonies using procedure described by Leslie and Summerell (2006). Non-sporulating colonies resembling *F. graminearum* were transferred to water agar (WA), from which isolates were obtained using the hyphal tip method (Leslie and Summerell, 2006).

A concept described by Summerell et al. (2003) was used in identification of the isolates. *F. avenaceum* was identified according to the morphology on potato-dextrose agar (PDA) and carnation leaf agar (CLA), using the descriptions of Lević (2008) and Leslie and Summerell (2006). Six *F. avenaceum* isolates (F85A, FC6, FC7, F32, F35 and FJA) were used in this study. *F. graminearum* was also identified according to the morphology on PDA and CLA, but several isolates did not produce perithecia on carnation leaves. To avoid the misidentification with *Fusarium pseudograminearum*, such isolates were grown on carrot agar (CA) in conditions described by Leslie and Summerell (2006). Isolates producing perithecia on CA were determined as *F. graminearum*, and 13 isolates (FA5, FA6, FA10, FA11, FA12, F50A, F54A, F29B, F44B, FP5, F16, F27 and F4III) were used in this study. Eight isolates identified as *F. verticillioides* according to the morphology on PDA and CLA, were further analysed by PCR using primer pairs VER1/VER2, as described by Mulè et al. (2004). Briefly, DNA from isolates was extracted using DNeasy Plant Mini Kit® (Qiagen Inc., USA), and approximately 4 ng of fungal DNA was used in 50 μl reaction mixtures. The content of chemicals in reaction mixtures, PCR conditions and electrophoresis were the same as described by Mulè et al. (2004). Seven of the eight isolates were confirmed by PCR as *F. verticillioides*, and six of them (FA21, F52A, F25, F6III, F8III and SRPII/6) were used in this study.

Fungicides used, media preparation and inoculation

Active ingredients of fungicides in the study were obtained by using the commercial products Bavistin FL (carbendazim, BASF®, Germany), Impact (flutriafol, Cheminova®, Denmark), Folicur EW 250 (tebuconazole, Bayer CropScience®, Germany), Sportak 45 EC (prochloraz, Bayer CropScience®, Germany), and Caramba (metconazole, BASF®, Germany). Stock solutions of each fungicide were prepared in sterile water, after which aliquots of stock solutions were added to PDA cooled to approximately 50°C. All fungicides were added in PDA in concentrations of 10 mg l^{-1}, 3.3 mg l^{-1}, 1 mg l^{-1}, 0.33 mg l^{-1} and 0.1 mg l^{-1}.

Prior to inoculation on PDA with fungicides, *Fusarium* isolates were grown on WA for several days. Mycelial discs 10 mm in diameter were cut off from the WA colonies and placed in the centre of PDA amedned with fungicides, and control PDA plates without fungicide. Assay was performed in two replicates, in Petri dishes with 10 cm diameter. Plates were incubated at 22°C in darkness, and growth of isolates was measured in mm at the underside of the colonies after 3 and 7 days. For each isolate, mean values from two replicates were used in data analysis.

Assay on fungal growth and data analysis

Relative inhibition of growth (%) was calculated for each isolate, fungicide and concentration by using the growth data values measured after 7 days on control plates and plates amended with fungicides. Concentration of fungicides which reduced mycelial growth of isolates by 50% (EC_{50}) was calculated by regressing relative growth inhibition values (dependent data, y-value on regression plot) against the $\log_{10}$-transformed fungicide concentrations (independent data, x-value on regression plot). Linear trendline was generated on regression plots, and $\log_{10}EC_{50}$ was determined by appointing $\log_{10}$ interception of a linear trendline corresponding to relative growth inhibition value of 50%. EC_{50} values were calculated as an antilog$_{10}$ of $\log_{10}EC_{50}$ values.

In order to further compare the effectiveness of fungicides included in the study, relative growth inhibition of *Fusarium* species on each fungicide and concentration was analysed using analysis of variance (ANOVA). Means were separated using Duncan's New Multiple Range Test (P=0.05). ANOVA was also used to determine the eventual significant differences in sensitivity to the fungicides among isolates of the same species. In this analysis, growth inhibition of all isolates of the same species (*F. graminearum*, *F. avenaceum* or *F. verticillioides*) was compared on each fungicide separately, with all concentrations included. Prior to each ANOVA, relative growth inhibition values were transformed using the arcsin transformation. SAS® 9.1 software was used for all data analysis.

RESULTS

Fusarium isolates included in the study showed different reaction to different fungicides (Tables 1 and 2). Prochloraz showed the highest inhibition of growth of three *Fusarium* species investigated, with EC_{50} values lower than 0.1 mg l^{-1} in all isolates (Table 1). Beside prochloraz, EC_{50} values lower than 0.1 mg l^{-1} was recorded only on metoconazole, for two isolates of *F. graminearum*, one isolate of *F. avenaceum*, and five out of the six *F. verticillioides* isolates. EC_{50} values recorded on carbendazim and tebuconazole were higher than on metoconazole, except in cases of *F. graminearum* FA10 and F44B isolates on tebuconazole and *F. graminearum* FA10, F44B, F4III and FP5 isolates on carbendazim. EC_{50} values on carbendazim ranged from 0.39 mg l^{-1} to 1.41 mg l^{-1}, while on tebuconazole a range between 0.22 mg l^{-1} and 2.57 mg l^{-1} was recorded. Flutriafol showed the lowest growth inhibition of all *Fusarium* species and isolates tested, with EC_{50} values higher than 10 mg l^{-1} recorded in seven isolates (four *F. graminearum* and three *F. avenaceum*). For other isolates, EC_{50} values on flutriafol were in all cases higher than on other fungicides included in the study, ranging from 1.66 mg l^{-1} to 8.51 mg l^{-1}. Generally, isolates of *F. verticillioides* were shown to be the most sensitive to fungicides tested. Isolates of *F. avenaceum* were showed to be generally less sensitive to carbendazim, tebuconazole and flutriafol than most of the isolates of *F. graminearum*.

Table 1. EC_{50} values (mg l^{-1}) of *Fusarium graminearum*, *F. avenaceum* and *F. verticillioides* isolates grown on potato-dextrose media ammended with carbendazim, tebuconazole, flutriafol, metconazole and prochloraz

Species	Isolate	EC_{50}, mg l^{-1}				
		Carbendazim	Tebuconazole	Flutriafol	Metconazole	Prochloraz
F. graminearum	FA10	0.47	1.12	3.89	1.12	<0.1
	F44B	1.41	1.35	>10	1.66	<0.1
	FA5	0.60	1.45	>10	0.16	<0.1
	F4III	0.83	2.57	>10	1	<0.1
	F27	0.74	1	4.37	<0.1	<0.1
	FA11	0.41	1.05	8.51	0.35	<0.1
	F29B	0.72	1.62	>10	0.19	<0.1
	F54A	0.91	0.93	5.13	0.16	<0.1
	FA6	0.54	0.95	3.63	0.16	<0.1
	FP5	0.39	0.85	5.37	0.63	<0.1
	F50A	0.52	1.17	10	<0.1	<0.1
	F16	1	0.91	4.17	0.23	<0.1
	FA12	0.40	1.70	4.47	0.38	<0.1
F. avenaceum	FC6	0.91	1.17	5.25	<0.1	<0.1
	F32	1.35	1.05	>10	0.26	<0.1
	F35	1.26	1.23	>10	0.56	<0.1
	FC7	1.35	1.58	>10	0.19	<0.1
	FJAB	1.17	0.95	7.08	0.13	<0.1
	F85A	1.23	0.85	7.08	0.56	<0.1
F. verticillioides	F52A	0.54	0.29	2.40	<0.1	<0.1
	FA21	0.54	0.43	1.82	<0.1	<0.1
	F25	0.48	0.85	2.88	0.17	<0.1
	F8III	0.60	0.22	1.66	<0.1	<0.1
	F6III	0.55	0.60	2.24	<0.1	<0.1
	SRP 6	0.47	0.40	2	<0.1	<0.1

Table 2. Growth inhibition (%) of *Fusarium graminearum*, *F. avenaceum* and *F. verticillioides* on different concentrations of carbendazim, tebuconazole, flutriafol, metconazole and prochloraz

Fungicide	Concentration, mg l^{-1}				
	0,1	0,33	1	3,3	10
	Inhibition of growth, %				
	F. graminearum				
Carbendazim	0.0 c[1]	21.0 c	83.1 a	99.1 a	100 a
Tebuconazole	0.0 c	23.0 c	50.1 b	71.2 b	87.8 b
Flutriafol	0.0 c	0.0 d	3.5 c	39.0 c	65.6 c
Metconazole	30.3 b	52.8 b	70.4 a	79.3 b	100 a
Prochloraz	70.1 a	79.1 a	88.7 a	98.9 a	100 a
	F. avenaceum				
Carbendazim	0.0 c	0.0 d	31.6 c	92.0 a	100 a
Tebuconazole	0.7 c	35.5 c	46.2 b	73.3 b	84.3 b
Flutriafol	0.0 c	0.0 d	19.5 c	40.8 c	54.5 c
Metconazole	32.0 b	55.8 b	70.6 a	84.5 b	90.3 b
Prochloraz	62.3 a	75.5 a	86.6 a	97.6 a	100 a
	F. verticillioides				
Carbendazim	0.0 c	31.0 b	96.8 a	100 a	100 a
Tebuconazole	11.6 b	44.8 b	83.2 b	91.3 a	97.0 a
Flutriafol	0.0 c	0.8 c	30.6 c	64.5 b	81.5 b
Metconazole	69.6 a	81.0 a	92.3 a	99.3 a	100 a
Prochloraz	80.3 a	89.8 a	96.2 a	99.3 a	100 a
	All species				
Carbendazim	0.0 c	12.1 b	74.9 a	98.4 a	100.0 a
Tebuconazole	2.0 c	34.1 b	60.8 a	79.6 b	90.6 b
Flutriafol	0.0 c	0.1 c	16.5 b	48.4 c	68.2 c
Metconazole	43.9 b	63.9 a	78.8 a	89.8 ab	99.9 a
Prochloraz	71.2 a	81.9 a	91.0 a	98.7 a	98.9 a

[1] - values were arcsin transformed before analysis. Means within column followed by the same letter do not differ significantly (P=0.05)

Comparing the average growth inhibition of all *Fusarium* isolates on different concentrations of fungicides, prochloraz inhibited the growth of isolates for even 71.2%, metconazole for about 44%, while carbendazim, tebuconazole and flutriafol did not inhibited the growth of isolates on 0.1 mg/l concentration (Table 2) Prochloraz and metconazole significantly higher inhibited the growth of isolates on all the other concentrations in comparison with carbendazim, tebuconazole and flutriafol, while inhibition on flutriafol was in all cases significantly lower than inhibition on carbendazim or tebuconazole. Growth inhibition on carbendazim and tebuconazole was not singificantly different on concentrations of 0.33 mg l^{-1} and 1 mg l^{-1}, but the inhibition on carbendazim was significantly higher comparing it to tebuconazole on concentrations of 3.3 mg l^{-1} and 10 mg l^{-1}. Significant differences in sensitivity to fungicides were also determined for each *Fusarium* species analysed separately. Although data varied depending on concentration, prochloraz generally showed the highest effectiveness in growth inhibition of all three species, which was in several cases significantly higher compared to other fungicides. In many cases, flutraifol was shown to be significantly less effective than other fungicides included in the study.

There were no significant differences in growth among different isolates of the same *Fusarium* species on neither one of the fungicides tested (data not shown).

DISCUSSION

In this study, prochloraz was the fungicide which showed the best effect in inhibition of growth of *F. graminearum*, *F. avenaceum* and *F. verticillioides*, while flutriafol showed relatively poor effect comparing it to other fungicides. The results of this study are somewhat different from the results of similar *in vitro* studies, but also different if compared to the efficacy trials conducted in the field. In experiments of Jones (2005), neither one out of 50 *F. graminearum* isolates did not grow on agar with 10 mg l^{-1} of tebuconazole. In this study, even 12 out of 13 *F. graminearum* isolates still grew on 10 mg l^{-1} of tebuconazole in media. Matthies et al. (1999) reported over 90% inhibition of *F. graminearum* mycelial mass growth on 1 mg l^{-1} of tebuconazole, and about 40% inhibition of mycelial mass growth on 1 mg l^{-1} of carbendazim. In this study, the mean growth inhibition of *F. graminearum* isolates on 1 mg l^{-1} of tebuconazole was 50%, while it was 83% on the same concentration of carbendazim. However, the results of this study determined for fungicide tebuconazole were relatively similar to results of Müllenborn et al. (2008). In a similar experiment, ED_{50} values recorded for different *Fusarium* isolates on tebuconazole were from 0.24 mg l^{-1} to 6.5 mg l^{-1} (Müllenborn et al., 2008). In this study, ED_{50} values on tebuconazole ranged from 0.22 mg l^{-1} to 2.57 mg l^{-1}.

In Croatia, for the control of FHB in wheat, prochloraz-based fungicides are used at dose rate of 450 g a.i.$^{-1}$ per ha, tebuconazole at 125 to 250 g a.i.$^{-1}$ per ha, and carbendazim at 125 to 180 g a.i.$^{-1}$ per ha. Considering the results of this study, where prochloraz was the most effective in reducing *Fusarium* growth, it might be concluded that prochloraz would be the most efficient in the field, while tebuconazole and carbendazim would be more or less of equal effectiveness. However, several field trials recorded higher efficacy of tebuconazole compared to carbendazim and prochloraz. In the study of Ellner (1997), tebuconazole has shown to be more effective than prochloraz in control of FHB caused by *Fusarium culmorum* in field conditions. Similar results were recorded in other field study from Germany, where tebuconazole was also proven to be more effective than prochloraz (Matthies and Buchenauer, 2000). Tebuconazole reduced FHB severity by 56% and 43%, depending on the time of application, whereas prochloraz reduced disease severity for 41% and 22% (Matthies and Buchenauer, 2000). In the study of Siranidou and Buchenauer (2001), tebuconazole and metconazole were effective in control of FHB, while prochloraz and benzimidazole benomyl were not. In trials of Cromey et al. (2001), tebuconazole reduced FHB for 41%, while carbendazim reduced FHB for only 29% comparing it to control. Tebuconazole showed the best efficacy on FHB in trials of Mesterhazy and Bartok (1997), where a percentage of *Fusarium*-infected seed on variants treated with tebuconazole was 12%, while it reached even 42% on variants treated with carbendazim. Tebuconazole was also more effective than prochloraz in trials conducted in Croatia (Ivic et al., 2009). In trials conducted on four wheat cultivars in Italia, tebuconazole was more effective in control of FHB on two cultivars, while prochloraz showed better efficacy in other two cultivars (Menniti et al., 2003).

Cultivar response, temperature, persistence of fungicides on plant organs, sensitivity of fungal spores to fungicides, curative effects, or dynamics and extent of translocation of different systemic fungicidal compounds are only some of the features which condition the performance and efficacy of fungicides in field conditions (Jones, 2000; Simpson et al., 2001; Pirgozliev et al., 2002). Such characteristics can be especially important in control of a certain plant disease, and especially of FHB. This is why the effect of a fungicide *in vitro* may not reflect the efficacy of a product in practical conditions. Beside this, it must be mentioned that the results of many field efficacy trials remain unpublished, and that available data from several recent studies published in journals cannot give a comprehensive picture of a fungicide performance on a certain plant disease.

The response of different *Fusarium* species to the fungicides tested in this study varied, which was expected. Reaction of a fungal strain or an isolate to the certain fungicidal compound is a phenotypic characteristic which is always variable in populations of plant pathogenic fungi, and this is proven in numerous other laboratory studies. In already mentioned study of Müllenborn et al. (2008), different ED_{50} values were recorded for seven different *Fusarium* species grown on media with prothioconazole, tebuconazole, azoxystrobin and fluoxastrobin. Differences in reaction of different *Fusarium* species to the fungicides *in vitro* was also recorded in the study of Allen et al. (2004), where *Fusarium solani* was inhibited by 60% on difenconazole amended media, while *Fusarium circinatum*, *F. oxysporum* and *F. proliferatum* were inhibited by 90%. Indirect evidence for different sensitivity of different *Fusarium* species to a certain fungicide are shown in studies of Pirgozliev et al. (2002) and Simpson et al. (2001). FHB severity on variants artificially inoculated with *F. culmorum* and treated with metconazole was higher than on variants inoculated with *F. graminearum* and treated with the same fungicide (Pirgozliev et al., 2002). Tebuconazole significantly reduced the amount of *F. graminearum* and *F. culmorum*, but not of *F. avenaceum*, in conditions of natural and artificial infections of wheat heads (Simpson et al., 2001).

In this study, no differences between isolates of the same species were recorded, which means that no decreased sensitivity or resistance was noted among isolates tested. Considering the common agricultural practice of wheat cultivation in Croatia and in Europe in general, it can be concluded that the risk of resistance of *Fusarium* species causing FHB is very low. In Croatia, fungicides are applied on wheat one to three times during the vegetation, products with two different fungicidal compounds are commonly used today, and wheat is almost never cultivated in monoculture.

The results of this study have shown significant differences in sensitivity of *Fusarium* species to carbendazim and four DMI fungicides commonly used in management of FHB. Beside this, differences in reaction to the fungicides were recorded among three distinct and economically important *Fusarium* species, *F. graminearum*, *F. avenaceum* and *F. verticillioides*. This study can be regarded as a supplement to the fungicide efficacy trials conducted in the field. Beside this, data from this study can be useful in defining the strategy for integrated management of FHB, where chemical control is still one of the basic measures implemented in most of the wheat-growing areas in the world.

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In vitro osetljivost vrsta *Fusarium graminearum, F. avenaceum* i *F. verticillioides* na karbendazim, tebukonazol, flutriafol, metkonazol i prohloraz

REZIME

U istraživanju je ispitan rast 13 izolata *Fusarium graminearum*, 6 izolata *F. avenaceum* i 6 izolata *F. verticillioides* na krompir-dekstroznoj podlozi s dodatkom 0,1, 0,33, 1, 3,3 i 10 mg/l karbendazima, tebukonazola, flutriafola, metkonazola i prohloraza. Za svaki izolat izračunata je srednja efektivna koncentracija (EC_{50}), pri kojoj je prosečni rast izolata bio inhibiran za 50% u odnosu na kontrolu. Prohloraz je bio najučinkovitiji u inhibiciji rasta sve tri vrste, dok je flutirafol pokazao najmanju učinkovitost. Metkonazol je pokazao višu učinkovitost u poređenju s karbendazimom i tebukonazolom. EC_{50} vrednosti svih izolata na prohlorazu bile su manje od 0,1 mg/l, dok su na flutriafolu varirale između 1,66 i 8,51 mg/l za 18 izolata, ili bile veće od 10 mg/l za sedam izolata. EC_{50} vrednosti na karbendazimu bile su 0,39-1,41 mg/l za izolate *F. graminearum,* 0,91-1,35 mg/l za *F. avenaceum*, te 0,47-0,6 mg/l za *F. verticillioides*. Na tebukonazolu EC_{50} vrednosti bile su 0,85-2,57 mg/l za *F. graminearum*, 0,85-1,58 mg/l za *F. avenaceum* i 0,22-0,85 mg/l za *F. verticillioides*, dok su na metokonazolu utvrđene EC_{50} vrednosti između manjih od 0,1 do 1,66, 0,56 i 0,17 mg/l za *F. graminearum, F. avenaceum* i *F. verticillioides*. Prosečne inhibicije rasta različitih *Fusarium* vrsta i svih *Fusarium* izolata ukupno na različitim koncentracijama različitih fungicida značajno su se razlikovale. Nisu utvrđene značajne razlike u rastu između izolata unutar pojedinih *Fusarium* vrsta na niti jednom od ispitanih fungicida, što pokazuje da ne postoji smanjena osetljivost na fungicide kod izolata uključenih u istraživanje.

Ključne reči: *Fusarium*; karbendazim; tebukonazol; flutriafol; metkonazol; prohloraz