ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 12(5) 2013, 69-83*

HARMFULNESS OF *Phomopsis diachenii* Sacc. TO HERBS FROM Apiaceae FAMILY AND PREPARATIONS LIMITING THE GROWTH OF THIS FUNGUS

Ewa D. Zalewska, Zofia Machowicz-Stefaniak, Ewa D. Król
University of Life Sciences in Lublin

Abstract. *Phomopsis diachenii* belongs to the fungi increasingly noted on herbal plants from Apiaceae family. Considering the documented fungal pathogenicity for herbs, the possibility of limiting the growth and development of *P. diachenii* was studied. Two biotechnical preparations i.e. Biosept Active and Beta-chikol and 12 fungicides from different chemical groups as well as one isolate of *P. diachenii* K 651, obtained from caraway were used for the study. Tests were performed by poisoning the culture media with each of the tested preparations, which were then inoculated with the *P. diachenii* inoculum. The percentage of inhibition of the growth of four- and eight-day-old fungus colonies on the medium with preparations in comparison to the control colonies was a measure of the toxic activity of the preparations. The effectiveness of Beta-chikol in limiting *P. diachenii* growth was significantly higher than the efficiency of Biosept Active. All fungicides limited the growth and development of *P. diachenii*, and the effectiveness of inhibitory activity was correlated with the concentration of the active ingredient in fungicide. The most promising compound in reducing the growth and development of *P. diachenii* was mancozeb.

Key words: caraway, angelica, Biosept Active, Beta-chikol, fungicides

INTRODUCTION

The fungi from *Phomopsis* genera form conidia in a single-chamber or complex conidiomata with thick walls. Numerous species produce the teleomorph stage, belonging to the genus *Diaporthe* [Marcinkowska 2010, Kačergius et al. 2011, Udayanga et al. 2011]. *Phomopsis* spp. occur in different geographical areas. *P. foeniculi* was recorded on dill in France, Italy and in Germany [Mugnai and Anzidei 1994, Kusterer et al. 2002]. *P. diachenii* was discovered on parsnip [Saccardo 1915, Sutton 1980, Farr et al. 1995], and since 1998 the fungus has occurred on caraway in Germany, where it is the reason for the browning and dieback of caraway umbels [Gabler and Ehrig 2000]. The

Corresponding author: Ewa D. Zalewska, Department of Plant Pathology and Mycology, University of Life Sciences in Lublin, Leszczyńskiego 7, 20-069 Lublin, e-mail: ewa.zalewska@up.lublin.pl

presence of this fungus on caraway in the Czech Republic, Bulgaria, Lithuania and in Poland, especially during the warmer growing season, was noted in recent years [Rodeva and Gabler 2004, Machowicz-Stefaniak 2009, Mačkinaitė 2010, 2012]. The genus includes both saprotrophic species and plant pathogens [Marcinkowska 2010, Udayanga et al. 2011]. Pathogenicity tests showed the possibility of *P. diachenii* isolates causing the necrosis of schizocarps, shoots, stems and leaves of caraway [Machowicz-Stefaniak et al. 2012a]. In the face of the increasing economic importance of *P. diachenii* for caraway and other species of herbs, a need arose to test the possibility of limiting the growth and development of the pathogen.

MATERIAL AND METHODS

The origin of the fungus. *P. diachenii* cultures were isolated from various organs of caraway as the result of the studies on the diseases of this plant in 2005–2007 and from angelica in the years 2008–2011. The isolation of the fungus was carried out using artificial cultures method on malt medium (Difco) with an addition of antibiotic – 0.01% streptomycin [Gabler and Ehrig 2000]. One-spore pure culture of the fungus were grown on PDA medium [Machowicz-Stefaniak 2009, Zalewska et al. 2013]. Strain K 651, obtained from caraway and tested earlier in terms of its pathogenicity (phot. 1) and life requirements, was selected for further studies [Machowicz-Stefaniak at al. 2012a, 2012b].

The effect of preparations on *P. diachenii.* *In vitro* tests were carried out taking into account the biotechnical preparation, i.e. Biosept Active Beta-chikol, 12 fungicides of different chemical groups and an isolate of *P. dichenii*. The list of the tested preparations according to the recommendations of Plant Protection for the years 2008/2009 and 2010/2011 is shown in tab. 1. Experiments were performed in two series. The method of poisoning the culture media and inoculating the fungal inoculum on them was applied

Table 1. List of examined preparations

No.	Preparations	Name of active ingredient and its content in the preparations	Producer
1.	Biosept Active	33% extract from grapefruit	Cintamani
2.	Beta-chikol	20 g·l^{-1} chitosan	Gumitex Poli-Farm
3.	Amistar 250 SC	250 g·l^{-1} – azoxystrobin	Syngenta LTD
4.	Bravo 500 SC	500 g·l^{-1} – chlorothalonil	Syngenta LTD
5.	Captan 50 WP	50% – captan	ARYSTA LS
6.	Curzate M 72.5 WP	4.5% – cymoksanil; 68% – mancozeb	DU PONT
7.	Curzate Cu 49.5 WP	4.5% – cymoksanil; copper oxichloride 45%	AZOT
8.	Dithane Neo Tec 75 WG	75% mancozeb	Dow AgroSciences
9.	Domark 100 EC	100 g·l^{-1} tetraconazole	ISAGRO
10.	Gwarant 500 SC	500 g·l^{-1} chlorothalonil	ARYSTA
11.	Sadoplon 75 WP	75% thiuram	AZOT
12.	Signum 33 WG	26.7% boskalide (anilide) 6.7% pyraclostrobin (strobilurine)	BASF
13.	Topsin M 500 SC	500 g·l^{-1} tiophanate methyl	NIPPON SODA
14.	Zato 50 WG	50% trifloxystrobin	BAYER AG

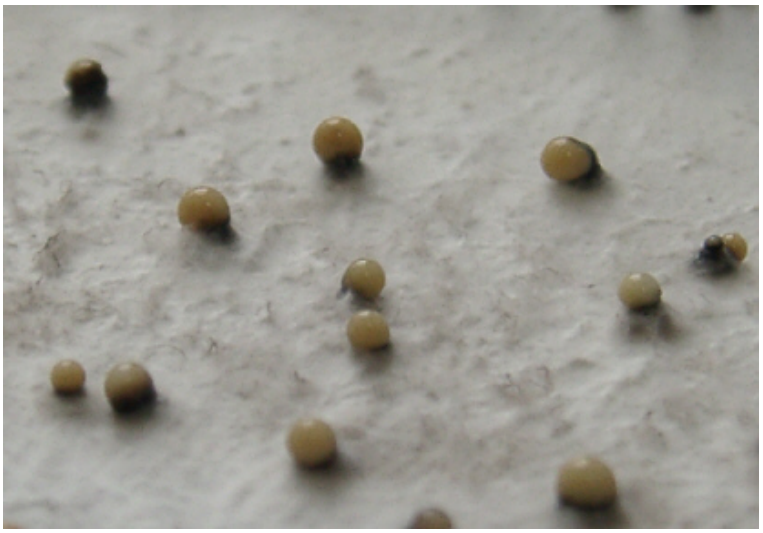
Phot. 1. Leaves and stems of caraway after inoculation with water suspension of conidia *P. diachenii* K 651 – a, c; control – b, d (photo E. Zalewska)

for the study [Borecki 1984, Machowicz-Stefaniak and Zalewska 2011]. Biosept Active was tested at the concentrations of 0.05%, 0.1%, 0.2% and 0.3%, while Beta-chikol at 0.01%, 0.025%, 0.05% and 0.1%. The fungicides were tested at the concentrations of 1 $g \cdot cm^{-3}$, 10 $g \cdot cm^{-3}$ and 100 $g \cdot cm^{-3}$ a.i., with the aim of determining an approximate ED_{50} dose and including them within one of four groups of fungicidal activity [Borecki 1984]. The experiments were established and conducted as described by Machowicz-Stefaniak and Zalewska [2011]. The measure of the toxic activity of the tested preparations was estimated as a percentage of inhibition of 4- and 8- day-old colonies in the preparations in relation to the control colonies [Kowalik and Krechniak 1961]. The microscopic observations of 4- and 8 day-old colonies of *P. diachenii* were conducted with the aim of detecting the changes in the morphological structures of the fungus on the medium with an addition of preparations. Moreover, the type of the toxic effect on *P. diachenii* for all preparations was determined [Borecki 1984].

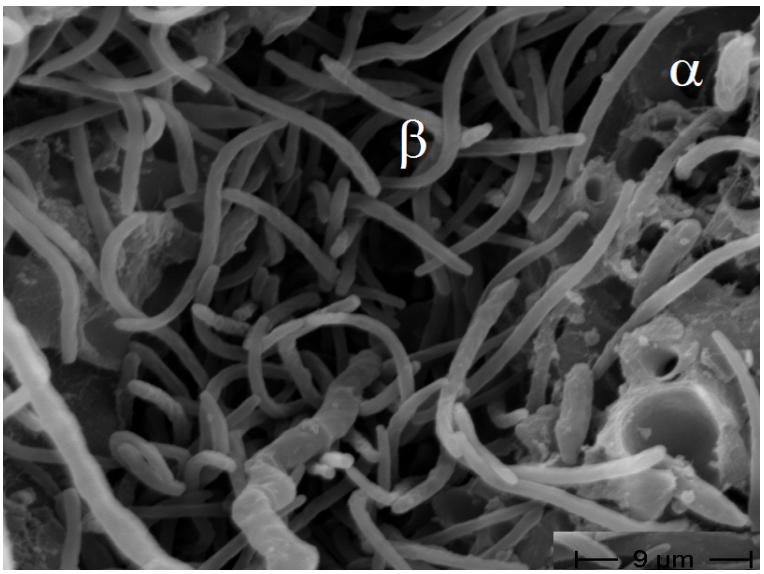
RESULTS

The cultures of *P. diachenii* (photos 2, 3 and 4) were obtained from caraway (*Carum carvi*) and angelica (*Archangelica officinalis*) plants, as the result of studies on the diseases of these plants. In the case of cumin, several isolates of the fungus were obtained from the roots and root collar of six-week-old seedlings in 2006, and a number of isolates in 2007 from the stems of plants in the second year of cultivation. The studied fungus was isolated only in 2010 year from angelica umbels at the beginning of schizocarps ripening. At that time, the temperature was up to 28°C and little rainfalls were often noted.

Phot. 2. 21-days-old colony of *P. diachenii* K 651 on PDA (photo E. Zalewska)



Phot. 3. Exudate of conidia from conidiomata of *P. diachenii* K 651 na PDA (photo E. Zalewska)



Phot. 4. Conidia (α, β) *P. diachenii* K 651 SEM (photo M. Wróbel)

The obtained 22 isolates of the fungus constituted 22.68% of all isolates of the fungi obtained from angelica umbels (fig. 1). *P. diachenii* was isolated from caraway and angelica plants cultivated in the field conditions, and no specific disease symptoms were observed on the plants.

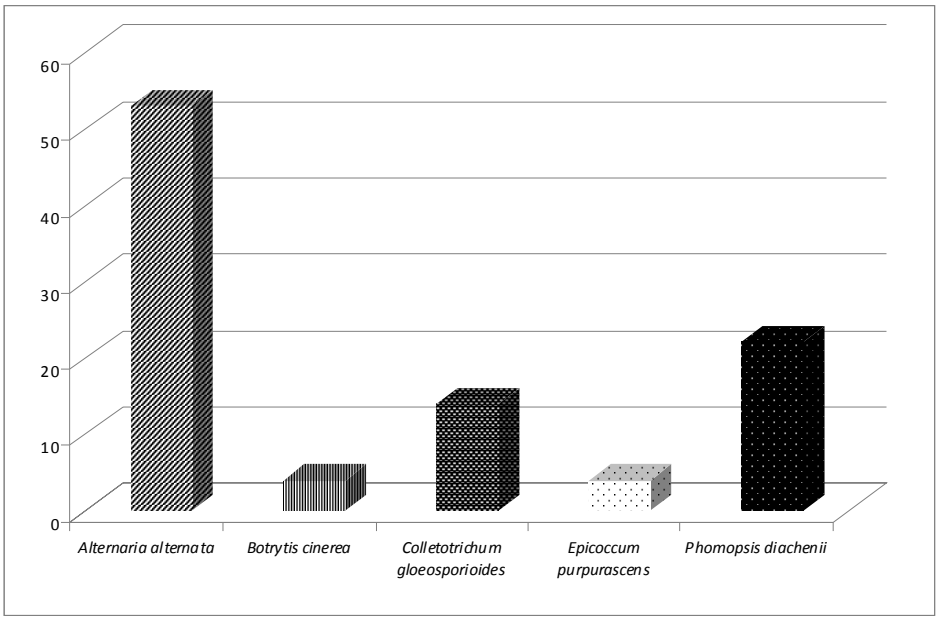


Fig. 1. Participation of *P. diachenii* among the fungi isolated from angelica umbels in 2010 year

The studies on the possibility of limiting the growth of *P. diachenii* showed that the percent of inhibition of the growth of 4-day-old colonies was significantly higher on the medium with an addition of Biosept Active, independently of the concentration of the preparation, than in control (tab. 2). The percentage of growth inhibition at the concentration of 0.3% of Biosept Active was significantly higher than at the concentrations of 0.1 % and 0.05%, while at the concentrations of 0.2% and 0.1% of the preparation it was significantly higher than at 0.05% (tab. 2).

Table 2. Impact of the biotechnical preparations on the growth of *P. diachenii* colony

Preparations	Concentration	Effect after 4 days	Effect after 8 days
Biosept Active	0.05%	21.17 C	9.17 C
	0.1%	37.57 B	26.95 B
	0.2%	44.45 AB	30.56 AB
	0.3%	47.09 A	35.56 A
	control	0.0 D	0.0 D
	LSD	7.4047	7.9355
Beta-chikol	0.01%	31.75 B	47.22 B
	0.025%	91.53 A	95.0 A
	0.05%	91.53 A	95.56 A
	0.1%	93.65 A	96.67 A
	control	0.0 C	0.0 C
	LSD	6.8279	7.4683

Values marked with the same letter do not differ significantly. $p \leq 0.05$

Table 3. Effect of fungicides tested on growth inhibition of 4-days-old colonies of *P. diachenii*

	Fungicides*	Percent of inhibition in relation to a.i. concentration (ppm)			LSD
		1 g·cm^{-3} a.i.	10 g·cm^{-3} a.i.	100 g·cm^{-3} a.i.	
II	Dithane NeoTec 75 WG	$8.94^{bcd}{}_{B}$	$100^{a}{}_{A}$	$100^{a}{}_{A}$	3.018
	Domark 100 EC	$-0.53^{d}{}_{C}$	$74.21^{b}{}_{B}$	$100^{a}{}_{A}$	5.4525
	Curzate M 72.5 WP	$15.79^{b}{}_{C}$	$67.37^{b}{}_{B}$	$100^{a}{}_{A}$	16.217
	Sadoplon 75 WP	$34.21^{a}{}_{C}$	$62.63^{b}{}_{B}$	$100^{a}{}_{A}$	7.5218
	Signum 33 WG	$40.0^{b}{}_{B}$	$62.10^{b}{}_{A}$	$68.95^{b}{}_{A}$	7.4918
	Bravo 500 SC	$9.99^{bcd}{}_{B}$	$59.99^{b}{}_{A}$	$74.74^{b}{}_{A}$	16.202
III	Topsin M 500 SC	$-22.10^{e}{}_{B}$	$-19.99^{f}{}_{B}$	$100^{a}{}_{A}$	5.4559
	Gwarant 500 SC	$8.42^{bcd}{}_{B}$	$42.10^{c}{}_{A}$	$63.16^{bc}{}_{A}$	29.683
IV	Captan 50 WP	$-2.10^{d}{}_{B}$	$-2.10^{de}{}_{B}$	$47.37^{c}{}_{A}$	19.293
	Amistar 250 SC	$0.0^{cd}{}_{B}$	$-2.10^{de}{}_{B}$	$21.05^{d}{}_{A}$	7.7164
	Curzate Cu 49.5 WP	$-16.84^{e}{}_{B}$	$-10.52^{ef}{}_{A}$	$19.99^{de}{}_{A}$	7.3301
	Zato 500 WG	$12.10^{bc}{}_{A}$	$12.63^{d}{}_{A}$	$16.13^{de}{}_{A}$	10.975
Control		0.0^{cd}	0.0^{de}	0.0^{e}	
LSD		12.41	14.817	20.815	

Capital letters – differences at the studied concentration a.i. of studied fungicide; small letters – differences at the some concentration a.i. of fungicides; values marked with the same letter do not differ significantly; * – fungicides compared according to fungicidal activity group

Table 4. Effect of fungicides tested on growth inhibition of 8-days-old colonies of P. diachenii

	Fungicides*	Percent of inhibition in relation to a.i. concentration (ppm)			LSD
		1 g·cm^{-3} a.i.	10 g·cm^{-3} a.i.	100 g·cm^{-3} a.i.	
II	Dithane NeoTec 75WG	$0^{b}{}_{B}$	$100^{a}{}_{A}$	$100^{a}{}_{A}$	0
	Domark 100 EC	$0^{b}{}_{C}$	$60^{b}{}_{B}$	$100^{a}{}_{A}$	2.6338
III	Signum 33 WG	$26.94^{a}{}_{C}$	$54.44^{c}{}_{B}$	$61.1^{b}{}_{A}$	4.6641
	Curzate M 72.5 WP	$0^{b}{}_{C}$	$24.44^{de}{}_{B}$	$100^{a}{}_{A}$	10.746
	Topsin M 500 SC	$0^{b}{}_{B}$	$0^{f}{}_{B}$	$100^{a}{}_{A}$	8.88
	Sadoplon 75 WP	$0^{b}{}_{C}$	$21.11^{de}{}_{B}$	$93.89^{a}{}_{A}$	2.8334
	Bravo 500 SC	$0^{b}{}_{C}$	$26.94^{d}{}_{B}$	$54.16^{b}{}_{A}$	19.722
IV	Gwarant 500 SC	$0^{b}{}_{C}$	$16.39^{e}{}_{B}$	$34.16^{c}{}_{A}$	15.08
	Captan 50 WP	$0^{b}{}_{B}$	$0^{f}{}_{B}$	$28.05^{cd}{}_{A}$	4.1858
	Curzate Cu 49.5 WP	$0^{b}{}_{B}$	$0^{f}{}_{B}$	$16.11^{de}{}_{A}$	2.1969
	Zato 500 WG	$1.66^{b}{}_{B}$	$4.16^{f}{}_{B}$	$9.99^{ef}{}_{A}$	3.5626
	Amistar250 SC	$0^{b}{}_{B}$	$0^{f}{}_{B}$	$7.77^{ef}{}_{A}$	2.3141
Control		0^{b}	0^{f}	0^{f}	
LSD		2.2479	8.2379	14.986	

Explanations like in table 3

The inhibitory effect of Biosept Active after 8 days was weaker than after 4 days. However, the percentage of inhibition of 8-day-old colonies was significantly greater than in the control, independently of the concentration of the preparation. Moreover, the percentage of inhibition of 8-day-old colonies on the medium with 0.3% concentration of Biosept Active a.i. was significantly higher than in the presence of 0.1 and 0.05% of a.i. (tab. 2). Colonies in the presence of this preparation had macroscopic and microscopic features similar to the control colonies. The conidiomata were not observed till the 8th day of cultivation.

The percentage of growth inhibition of 4-day-old colonies of *P. diachenii,* growing in the presence of Betach-chicol preparation, was significantly higher than in the control (tab. 2). The percentage of growth inhibition was significantly higher at the concentrations of 0.1%, 0.05% and 0.025% than at 0.01% of the preparation after 4 days and after 8 days (tab. 2). The colonies of *P. diachenii* growing in the presence of Beta-chikol were strongly reduced and had a residual aerial mycelium. The conidiomata were not observed in the microscopic slide, and single chlamydospores were formed along the hyphae.

Table 5. Effect of fungicides on the growth of *P. diachenii* colony independently of active ingredients concentration

Fungicides	Percent of inhibition	
	after 4 days	after 8 days
Dithane NeoTec 75 WG	69.64 A	66.67 A
Sadoplon 75 WP	65.61 AB	38.33 DE
Curzate M 72.5 WP	61.05 AB	41.48 D
Domark 100 EC	57.89 B	55.37 B
Signum 33 WG	57.02 BC	47.49 C
Bravo 500 SC	48.24 C	27.03 F
Gwarant 500 SC	37.89 D	16.85 G
Topsin M 500 SC	19.30 E	33.33 E
Captan 50 WP	14.38 EF	9.35 H
Zato 50 WG	13.62 EF	5.27 HI
Amistar 250 SC	6.32 FG	2.59 I
Curzate Cu 49.5 WP	-2.47 G	5.37 HI
Control	0 G	0 I
LSD	9.0862	5.5174

Values marked with the same letters do not differ significantly

From among 12 fungicides tested, after 4 days of *P. diachenii* cultivation on the medium with an addition of the preparations, only 6 were included within Group II of toxic activity, i.e. within the substances of strongly fungicidal activity. Totally, i.e. 100% fungal growth inhibition was caused by Neotec Dithane WG 75 used at the concentra-

tions of 10 g·cm^{-3} and 100 g·cm^{-3}, and Domark 100 EC, Curzate 72.5 M WP and Sadoplon 75 WP used at the concentration of 100 g·cm^{-3} in this group of preparations (tab. 3). Group III of toxic activity, i.e. the substances of moderate fungicidal activity, included Topsin M 500 SC and Gwarant 500 SC. The former, at the concentrations of 1 g·cm^{-3} and 10 g·cm^{-3}, stimulated the growth of *P. dichenii* (tab. 3). Other four fungicides were included within the fourth group of fungicidal activity, i.e. within the substances of poor fungicidal activity (tab. 3).

After 8 day of the effect, the toxic activity of fungicides towards *P. diachenii* decreased. Three fungicides: Dithane NeoTec 75 WG, Domark 100 EC and Signum 33 WG remained in the second group of toxic activity, the third group consisted of four fungicides, and the fourth group comprised five fungicides (tab. 4). The percentage of growth inhibition of 8-day-old colonies in the presence of most fungicides at the concentration of 1 g·cm^{-3} a.i. was 0.0 (tab. 4). Significantly, the greatest inhibition of 8-day-old colonies of *P. diachenii* was caused by Dithane NeoTec 75 WG (photo 5), Domark 100 EC, Curzate M 72.5 WP (phot. 6), Topsin M 500 SC and Sadoplon 75 WP, applied at the concentrations of 100 g·cm^{-3} a.i. (tab. 4).

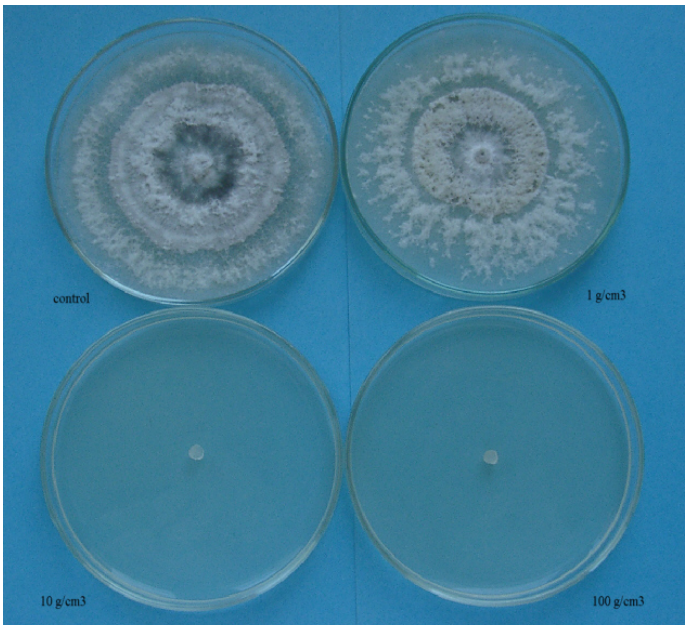
Significantly, the highest percentage of growth inhibition of 4-day-old colonies of *P. diachenii* was caused by Dithane NeoTec 75 WG, Sadoplon 75 WP, Curzate M 72.5 WP, Domark 100 EC and Signum 33 WG irrespective of a.i. concentration (tab. 5). On the other hand, irrespective of a.i. concentration the growth of 8-day-old *P. diachenii* colonies was inhibited by Dithane NeoTec 75 WG and Domark 100 EC (tab. 5).

The effect of most fungicides tested on the *P. diachenii* growth was fungistatic, both after four and 8 days (tab. 6). Fungicidal activity was shown by Dithane NeoTec 75 WG at the concentrations of 10 g·cm^{-3} and 100 g·cm^{-3} (tab. 6).

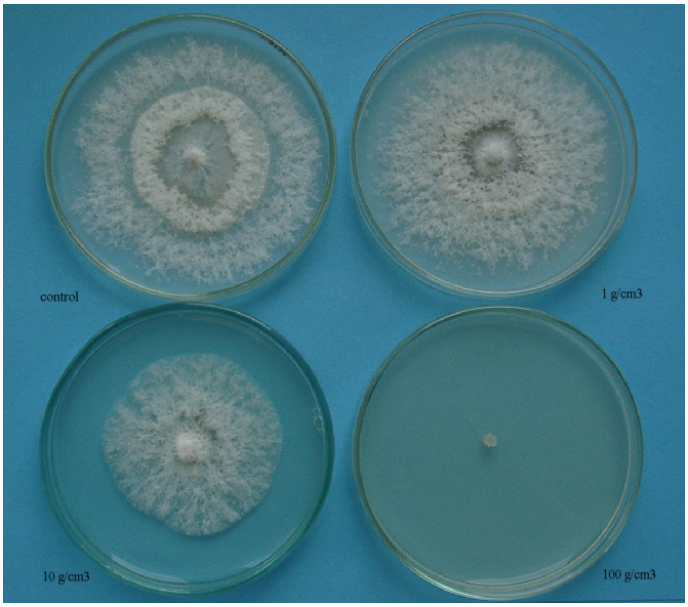
Table 6. The kind of toxic activity of fungicides on *Phomopsis diachenii*

Fungicides	Toxic activity		
	1 g·cm^{-3}	10 g·cm^{-3}	100 g·cm^{-3}
Amistar 250 SC	+	+	+
Bravo 500 SC	0	+	+
Captan 50 WP	0	0	+
Curzate M 72.5 WP	0	+	+
Curzate Cu 49.5 WP	+	+	+
Dithane NeoTec 75 WG	+	-	-
Domark 100 EC	0	+	+
Gwarant 500 SC	0	+	+
Sadoplon 75 WP	+	+	+
Signum 33 WG	+	+	+
Topsin M 500 SC	+	+	+
Zato 50 WG	+	+	+

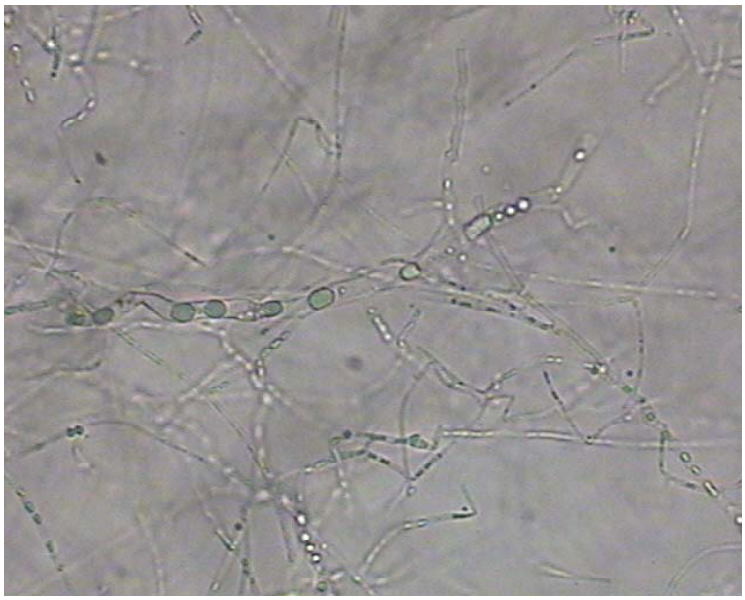
- – fungicidal activity
+ – fungistatic activity
0 – the lack of activity



Phot. 5. 8-days-old colonies of *P. diachenii* on the medium with an addition of fungicide Dithane NeoTec 75 WG (photo E. Zalewska)



Phot. 6. 8-days-old colonies of *P. diachenii* on the medium with an addition of fungicide Curzate M 72.5 WP (photo E. Zalewska)



Phot. 7. Liza of *P. diacheni* hyphae on the medium with fungicide Curzate M 72.5 WP in concentration 100 g·cm^{-3} (photo E. Zalewska)

Microscopic studies showed degeneration of *P. diachenii* hyphae after 8-day-long growth of the colonies on the medium containing 100 g·cm^{-3} s.a. of prepatation Curzate Cu 49.5 WP and after application of 10 g·cm^{-3} a.i of preparation Curzate M 72.5 WP (phot. 7). On the other hand, at the concentration of 1 g·cm^{-3} a.i. of the two above mentioned preparations and Zato 500 WG, Amistar 250 SC and Gwarant 500 SC the fungal hyphae formed coils, and even conidiomata with a few β conidia.

DISCUSSION

Periodically repeated occurrence of *P. diachenii* on caraway in recent years and the positive results of pathogenicity tests [Machowicz-Stefaniak et al. 2012a] indicate the harmfulness of the fungus and the rising threat to the herbs from Apiaceae family. This fact is confirmed by the isolation of the fungus from angelica umbels in Polish conditions and it indicats the polyphagic nature of the pathogen.

P. diachenii , like many other species, it is still not included among the pathogens in herbal plants protection programs. Therefore, it appears that the information about the factors affecting the growth and development of the pathogen is desirable. The obtained results indicate that the direct inhibitory effect of Biosept Active on *P. diachenii* was insufficient, even though biologically active substances are present in the preparation, including endogenous flavonoids inhibiting spore germination, and growth of vegetative as well as germination hyphae [Orlikowski et al. 2001a, b].

On the other hand, the tested preparation significantly limited the growth of *Colletotrichum dematium* and *C. gloeosporioides* and other fungi in contrast to the weak effect on *P. diachenii* [Machowicz-Stefaniak and Zalewska 2011, Pięta et al. 2004]. The effectiveness of preparations was correlated with the concentration in a small degree. However, it appears that the most effective concentration to inhabiting the growth of *P. diachenii* is 0.3%, when degeneration of hyphae was observed and which consequently prevents the formation of fungus conidiomata and spores. In the present study, the inhibiting effectiveness of Beta-chikol on *P. diachenii* was significantly higher than the efficiency of Biosept Active, which was not observed in relation to *C. dematium* and *C. gloeosporioides* [Patrejko 2009, Machowicz-Stefaniak and Zalewska 2011]. These facts indicate that the inhibitory effects of biotechnical preparations on phytopathogenic strains of fungi is variable and must be verified individually.

The conducted studies indicate large variation in the growth and development of the colonies of *P. diachenii* on the media containing various concentrations of the active ingredient of the tested fungicide.

It follows from the observations that the higher the concentration of the active substance, the higher percentage of colony growth inhibition. From among the twelve fungicides tested, all of them totally inhibited the growth of the fungus colony at the concentration of 100 $g \cdot cm^{-3}$. One of all fungicides tested, i.e. Dithane NeoTec 75 WG, containing 75% mancozeb, showed 100% inhibition of *P. diachenii* colonies growth also at the concentration of 10 $g \cdot cm^{-3}$. This fungicide showed similar effectiveness in relation to *Colletotrichum dematium* [Machowicz-Stefaniak and Zalewska 2011].

It was found that complete inhibition of the growth of *P. diachenii* by Dithane NeoTec 75 WG was a consequence of the fungicidal effect of the preparation on fungal colonies, which was shown in the present studies. This result was significantly correlated with the concentration of the active ingredients in the culture medium, but it was not dependent on the time of the effect on fungal colonies, which in the case of other species was established by Król [2005] and Machowicz-Stefaniak and Zalewska [2011]. It was observed that the element determining the fungicidal properties is mancozeb present in preparations Dithane NeoTec 75 WG at 75% of a.i. and in Curzate M 72,5 WP at 68% of a.i.

The present results are comparable to those obtained by Machowicz-Stefaniak and Zalewska [2011]. The afore mentioned authors tested the same preparations and fungicides with a similar chemical composition in relation to *C. dematium*. High fungicidal activity of mancozeb and its devastating effect on spores and vegetative mycelium was shown by Machowicz-Stefaniak et al. [1998] in relation to *Monilia coryli, Gloeosporium coryli* and *Seimatosporium hypericinum,* and Król [2005] in relation to *Phomopsis viticola*. The inhabiting effect of this preparation was also shown towards *Phoma anethi, Alternaria alternata* and F*usarium* spp, obtained from the seeds of caraway [Mačkinaitė 2012].

Mancozeb, which is present in the preparations Dithane NeoTec 75 WG and in Curzate M 72,5 WP, together with cymoxanil is a very effective compound for plant protection. It is a component of fungicides suitable both in spraying plantations and in dressing the seed potatoes, onions, seedlings and seeds [Miczulski 1991]. Cymoxanil contained in preparations Curzate M 72.5 WP and in Curzate Cu 49.5 WP in

a combination with copper shows weak limiting properties to fungal growth. These properties of cymoxanil were shown earlier in studies on limiting the growth of *Colletotrichum dematium* [Machowicz-Stefaniak and Zalewska 2011].

Determining the approximate ED_{50} dose, which is an indicator of toxicity of fungicide [Borecki 1980], in the present studies helped to include the tested fungicides within the groups of fungicidal activity against *P. diachenii.* The study shows that *P. diachenii* can be a difficult fungus to control. It seems that among the tested fungicides the most promising compound in reducing the growth and development of the pathogen is mancozeb, which is a part of various fungicides, but this hypothesis requires further investigation.

CONCLUSIONS

1. *Phomopsis diachenii* belongs to the fungi more often inhabiting various organs of herbs from Apiaceae family.
2. Biotechnical preparations and fungicides can be considered as factors limiting the growth and development of *P. diachenii.*
3. The effectiveness of the inhibitory effect of Beta-chikol towards *P. diachenii* significantly exceeded the efficiency of Biosept Active.
4. Among fungicides, mancozeb was considered as the most promising compound in the elimination of *P. diachenii*, because only this preparation showed the fungicidal activity.

ACKNOWLEDGEMENTS

The studies were supported by Ministry of Science and Higher Education, grant No NN310449938.

REFERENCES

Borecki Z., 1984. Fungicydy stosowane w ochronie roślin. PWN, Warszawa.

Farr D.F., Bills G.F., Chamuris G.P., Rossman A.Y., 1995. Fungi on plants products in the United States. St. Paul, Minnesota USA.

Gabler J., Ehrig F., 2000. *Phomopsis diachenii* Sacc. ein aggressiver Krankheitserreger an Kümmel (*Carum carvi* L.) – Erestanchweis für Deutschland. Z. Arzn. Gew. Pfl. 4(1), 36–39.

Kačergius A., Rodeva R., Gabler J., Stoyanova Z., 2011. Phylogenetic analysis of *Phomopsis* isolates from different host plants. XVIII Symposium of the Baltic Mycologists and Lichenologists. Lithuania, Dubingiai, September 19–23, Programme and Abstracts, 12–13.

Kowalik R., Krechniak R., 1961. Szczegółowa metodyka biologicznych i laboratoryjnych badań środków chemicznych. Materiały do metodyki biologicznej oceny środków ochrony roślin. IOR. Poznań, 63–91.

Król E., 2005. Influence of some chemicals on the variability of *Phomopsis viticola* Sacc. spores. J. Plant Prot. Res. 45(3), 195–204.

Kusterer A., Taubenrauch K., Gabler J., Kühne T., 2002. Krankheitsauftreten an Kümmel (*Carum carvi* L.), Fenchel (*Foeniclum vulgare* Mill.) und Dill (*Anethum graveolens* L.) am Standort Aschersleben. Z. Arzn. Gew. Pfl. 7(3), 387–391.

Machowicz-Stefaniak Z., 2009. The occurrence and biotic activity of *Phomopsis diachenii* Sacc. Acta Agrobot. 62(2), 125–135.

Machowicz-Stefaniak Z., Zalewska E., 2011. Occurrence of *Colletotrichum dematium* on selected herbs species and preparations inhibiting pathogen's growth and development *in vitro*. Ecol. Chem. Eng. S. 18(4), 465–478.

Machowicz-Stefaniak Z., Kuropatwa E., Zalewska E., Zimowska B., 1998. Toxic effect of fungicides on the pathogenic fungi of hazel. Progr. Plant Protect/Post. Ochr. Roślin 38(2), 544–546.

Machowicz-Stefaniak Z., Zalewska E., Król E., 2012a. Pathogenicity of *Phomopsis diachenii* Sacc. isolates to caraway *Carum carvi* L. (Apiaceae). Acta Sci. Pol. Hortorum Cultus 11(2), 185–202.

Machowicz-Stefaniak Z., Zalewska E., Król, E., Kowalik B., 2012b. Growth and development of *Phomopsis diachenii* Sacc. in different culture conditions. Acta Sci. Pol. Hortorum Cultus 11 (6), 69–80.

Mačkinaitė R., 2010. Fungi diversity on wild and cultivated common caraway (*Carum carvi* L.) seeds. Žemdirbystė=Agriculture 97(4), 73–84.

Mačkinaitė R., 2012. Potential pathogens of common caraway (*Carum carvi* L.) seeds and search for measures suppressing their spread. Žemdirbystė=Agriculture 99(2), 179–188.

Marcinkowska J., 2010. Oznaczanie rodzajów ważnych organizmów fitopatologicznych (*Fungi, Oomycota, Plasmodiophorida*). Wyd. SGGW, Warszawa.

Miczulski B., 1991. Podstawy praktycznej ochrony roślin. Wyd. AR, Lublin.

Mugnai L., Anzidei M., 1994. Casi di necrosi corticale da *Phomopsis foeniculi* del finoschio da seme in Italia. Petria 4(3), 237–244.

Orlikowski L.B., Skrzypczak Cz., Harnaj I., 2001a. Biological activity of grapefruit extract in the control of forme speciales of *Fusarium oxysporum*. J. Plant Prot. Res. 41(4), 104–111.

Orlikowski L.B., Skrzypczak Cz., Jaworska-Marosz A., 2001b. Influence of grapefruit extract on the growth and development of *Botrytis* spp. and grey mold development on lily and peony. Bull. Pol. Acad. Sci., Biol. Sci. 49(4), 373–378.

Patrejko M., 2009. Możliwość ograniczania wzrostu i rozwoju *Colletotrichum gloeosporioides* (Penz.) Sacc. za pomocą wybranych biopreparatów. Praca magisterska, UP w Lublinie.

Pięta D., Patkowska E., Pastucha A., 2004. Influence of biopreparations on growing and development of some pathegenic fungi. Acta Sci. Pol. Hortorum Cultus 3(2), 171–177.

Rodeva R., Gabler J., 2004. First report of *Phomopsis diachenii* in Bulgaria. Mycol. Balcanica 1, 153–157.

Saccardo P.A., 1915. Notae mycologicae. Annals Mycol. 13, 115–138.

Sutton B.C., 1980. The Coelomycetes. Fungi Imperfecti with Pycnidia, Acrevuli and Stromata. Comm. Mycol. Inst., Kew Surrey, England.

Udayanga D., Liu X., McKenzie E.H.C., Chukeatirote E., Bahkali A.H.A., Hyde K.D., 2011. The genus *Phomopsis*: biology, applications, species concepts and names of common phytopathogenes. Fungal Divers. 50, 189–225.

Zalewska E., Machowicz-Stefaniak E., Król E., 2013. Occurrence of fungi on *Angelica* plants *Archangelica officinalis* Hoffm. Acta Sci. Pol., Hortorum Cultus 12(2), 107–121.

SZKODLIWOŚĆ *Phomopsis diachenii* Sacc. DLA ZIÓŁ Z RODZINY APIACEAE I PREPARATY OGRANICZAJĄCE WZROST GRZYBA

Streszczenie. *Phomopsis diachenii* należy do grzybów coraz częściej notowanych na roślinach zielarskich z rodziny Apiaceae. Wobec udokumentowanej patogeniczności grzyba dla ziół, przebadano możliwości ograniczania wzrostu i rozwoju *P. diachenii.* Uwzględniono 2 preparaty biotechniczne: Biosept Active i Beta-chikol, 12 fungicydów z różnych grup chemicznych oraz szczep K 651 *P. diachenii*, uzyskany z kminku właściwego. Testy przeprowadzono metodą zatruwania podłoży hodowlanych każdym z preparatów i wszczepiania na nim inokulum *P. diachenii.* Miarą toksyczności preparatu był procent zahamowania wzrostu 4- i 8-dniowych kolonii grzyba na pożywce z preparatem w stosunku do kolonii kontrolnych. Efektywność hamującego oddziaływania Beta-chikolu na *P. diachenii* była znacznie większa niż efektywność Bioseptu Active. Wszystkie fungicydy ograniczały wzrost i rozwój *P. diachenii,* a efektywność hamującego działania była skorelowana ze stężeniem substancji aktywnej fungicydu. Za najbardziej perspektywiczny związek w ograniczaniu wzrostu i rozwoju *P. diachenii* uznano mankozeb.

Słowa kluczowe: kminek, arcydzięgiel, Biosept Active, Beta-chikol, fungicydy

Accepted for print: 22.02.2013