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FUNGI COLONIZING CARAWAY (*Carum carvi* L.) IN DIFFERENT REGIONS OF CULTIVATION

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Abstract. Repeated cultivation of caraway in the same agricultural regions creates favorable conditions to develop infectious diseases which reduce the quantity and quality of the herbal material. The aim of the present research was to determine the composition of fungi species colonizing different organs of caraway variety Konczewicki. Observations of plant healthiness were carried out, in the years 2011–2013, on plantations in the region of central and eastern Poland. The one-spore cultures of fungi were identified with good results on PDA or on standard media. A new fungus species *Mycocentrospora acerina* was detected for the first time in Poland. The fungus causes necrotic spots on the aboveground and underground parts of plants. An epidemic of caraway septoriosis caused by *Septoria carvi* occurred in the central region of Poland, during the hot and humid weather. At temperature reaching up to 28°C and low relative humidity an epidemic of powdery mildew *Erysiphe heraclei* appeared. Moreover, growing threat for caraway by *Colletotrichum* spp., causing anthracnosis as well as by soil fungi, i.e. *Sclerotinia sclerotiorum* and *Rhizoctonia solani* was shown.

Key words: caraway, healthiness of plants, fungi, cultivation, identification

INTRODUCTION

An increasing area of caraway (*Carum carvi* L.) cultivation promotes the occurrence of infectious diseases on plants, which reduce the quantity and quality of the herbal material. Pathogenic fungi have great importance in causing the disease of caraway in different geographical regions [Reuveni 1982, Evenhuis and Verdam 1997, Papas and Elena 1997, Gabler and Ehrig 2000, Bedlan 2005, Mačkinaitė 2012, Odstrčilová 2012].

The research on caraway disease conducted from 2001 in the Lublin region, in south eastern Poland, showed the presence of numerous species of fungi on caraway plants

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[Zalewska i Machowicz-Stefaniak 2003, Machowicz-Stefaniak and Zalewska 2004, 2008]. *Septoria carvi*, *Colletotrichum* spp., *Fusarium* spp., *Alternaria alernata*, *Boeremia exigua* and *Sclertotinia sclerotiorum* caused necrosis of the above-ground organs of the plant [Machowicz-Stefaniak and Zalewska 2008, Marcinkowska 2012]. The incidence of septoriosis was observed especially during warm and humid growing seasons, i.e. in 2001–2003. The thermal optimum for the growth and sporulation of *S. carvi* was from 20 to 25°C [Zalewska 2012]. The development of this pathogen on the above-ground parts of plants may be limited by other fast-growing species of fungi, because *S. carvi* is a weak competitor [Machowicz-Stefaniak et al. 2008]. Caraway plants may be colonized by other pathogenic fungi, among others, *Phomopsis diachenii* sporulating intensively at higher temperatures than *S. carvi*, i.e. from 22 to 28°C [Machowicz-Stefaniak et al. 2012]. *Sclerotinia sclerotiorum* occurred abundantly on the lower parts of the stems and roots of plants in the second year of cultivation, after a long period of rainfall. Therefore, environmental conditions determine the biodiversity of fungi and which pathogens will play a dominant role in a particular region of host plant cultivation [Gabler and Ehrig 2000, Machowicz-Stefaniak and Zalewska 2008]. The aim of the present study was to determine the composition of fungi species colonizing caraway in different regions of cultivation.

MATERIAL AND METHODS

Observations on healthiness of caraway plants cultivar Konczewicki were conducted in the years 2011–2013 on several plantations. In Świętokrzyskie province, the central region, in the villages Trębanów – 50°51'06''N 21°29'10''E and Małoszyce – 50°51'15''N 21°27'03''E, caraway was cultivated together with fodder peas. In the eastern border region in Wojsławice – 50°55'09''N 23°32'48''E, the plants grew with spring wheat. The area of caraway cultivation was from 0.8 to 11 hectares.

In Świętokrzyskie province the studies began in autumn 2011 on 5 plantations in the first year of cultivation and then continued in 2012, i.e. in the second year of cultivation during the flowering and harvest of schizocarps. Observations on plant healthiness were also conducted on two plantations of annual plants, which were founded in 2012, and then continued on the same plantation in 2013. In Wojsławice studies were carried out in 2012 on two plantations of caraway in the second year of cultivation.

The percentage of plants with disease symptoms on the above-ground organs and the percentage of leaves with symptoms of septoriosis were determined according to Machowicz-Stefaniak and Zalewska [2008]. The occurrence of fungi was determined both on the basis of etiological symptoms occurring on the diseased parts of the plants as well as the mycological analysis. The fungi were isolated from the previously disinfected plant material on maltose culture medium using the artificial culture method [Machowicz-Stefaniak and Zalewska 2008, Zalewska et al. 2013].

The one-spore cultures of fungi were identified on PDA or on standard media [Boerema et al. 2004, Leslie and Summerell 2006, Marcinkowska 2012]. The keys and monographs of different taxa were used for this purpose. The basis of the classification, was the method of Kirk et al. [2008] while the name of fungi species and the authors' epithets

Table 1. Comparison of average value of monthly temperature of air and rainfalls with average many years in vegetation periods in central region of Poland in 2011–2013

Month	Means of the years 1963–1992		Difference of mean air temperature in comparison with means of the years			Percentage of the average annual rainfalls		
	air temperature (°C)	rainfalls (mm)	2011	2012	2013	2011	2012	2013
January	-3.8	26.2	2.5	2.05	0.5	97.71	183.59	249.24
February	-2.9	27.3	-0.45*	-4.4*	1.8	75.46	86.08	103.30
March	1.1	27.1	1.95	3.05	-2.8*	28.04	80.07	205.54
April	7.4	40.4	2.4	1.5	0.4	61.39	84.41	38.62
May	13.3	54.4	-0.55*	0.3	0.95	100.37	113.79	252.02
June	16.5	68.9	1.55	0.9	1.45	82.00	89.40	124.09
July	18.0	78.3	-0.2*	2.3	0.65	288.63	79.18	15.71
August	17.1	73.7	1.3	1.6	1.4	55.09	54.27	36.23
September	12.9	47.3	1.8	1.7	-0.9*	10.99	53.70	153.28
October	7.8	41.0	0.4	0.5	1.9	57.32	256.8	25.12
November	2.5	40.9	0.2	2.55	2.5	1.0	80.19	144.7
December	-1.4	33.8	3.04	-2.0*	2.7	104.44	81.95	75.44

* – temperature lower than mean of the years

Table 2. Comparison of average value of monthly temperature of air and rainfalls with average many years in vegetation periods in east region of Poland in 2011–2013

Month	Means of the years 1963–1992		Difference of mean air temperature in comparison with means of the years			Percentage of the average annual rainfalls		
	air temperature (°C)	rainfalls (mm)	2011	2012	2013	2011	2012	2013
January	-3.8	26.2	-2.6	1.7	-0.2*	120.99	164.88	226.33
February	-2.9	27.3	-1.8*	-4.65*	1.75	95.24	70.33	130.03
March	1.1	27.1	1.7	3.5	-3.5*	28.71	94.83	205.16
April	7.4	40.4	3.7	1.95	1.0	85.40	77.23	113.36
May	13.3	54.4	0.1	0.75	1.55	100.73	59.93	200.73
June	16.5	68.9	1.6	0.8	1.55	114.95	60.38	165.17
July	18.0	78.3	0.55	3.0	0.4	218.01	53.38	113.15
August	17.1	73.7	1.25	1.65	1.7	42.47	60.11	22.79
September	12.9	47.3	1.95	2.2	-0.9*	11.20	81.18	86.89
October	7.8	41.0	0.25	0.15	2.3	66.34	209.2	14.87
November	2.5	40.9	-0.2*	2.8	2.85	2.44	55.26	154.52
December	-1.4	33.8	2.9	-2.8*	4.2	112.78	87.57	52.66

* – temperature lower than mean of the years

are given according to the current systemic taxonomic status of species basing on Index Fungorum from the year 2014. The results were analyzed in relation to weather conditions using the data published on-line [http://www.weatheronline.pl/] (tab. 1, 2).

RESULTS

In Świętokrzyskie province during the first year of plant cultivation symptoms of septoriosis were detected in autumn, i.e. in the second half of October 2011. The percentage of plants with symptoms of necrosis ranged from 30 to 80 depending on the plantation. They were necrotic spots appearing on the leaves and petioles and numerous pycnidia with thick, beige cirri of spores (fig. 1). The microscopic analysis of etiological symptoms showed abundant conidia of *Septoria carvi* (fig. 2). Those leaves died until the spring of the next year. At the time of caraway flowering in May 2012, the percentage of plants with disease symptoms was not changed. On the newly formed leaves symptoms of septoriosis appeared on 8–16% of them. At the same time on all plantations of biennial plants powdery mildew (*Erysiphe heraclei*), appeared abundantly. The surface of the above-ground parts of plants: stems, petioles and leaves were covered with a heavy, floury, white-gray color coating (fig. 3) containing the mycelium, conidiophores and conidia of oidium type (fig. 4). The conidia were fully viable, i.e. filled with fine-grainedcytoplasm, uniformly adhering to the cell wall. With time, the pathogen spread to the inflorescences, umbels and schizocarps, which resulted in significant weakening of plant health, small size of umbels and schizocarps and their premature falling off.

On caraway plantations in Wojsławice the percentage of plants with symptoms of septoriosis ranged from 8 to 16 at the time of the flowering. The presence of septoriosis was found on 5% of the leaves in the form of individual spots and a few pycnidia. Secretion of conidia was not observed. There was no powdery mildew of caraway in the studied region.

About 600 cultures of fungi, belonging to 21 species, were isolated in 2011 as a result of the mycological analysis of plants in the first year of cultivation (tab. 3). Isolates of *S. carvi* – 184, *Fusarium* spp. – 145, *Alternaria* spp. – 92, *Trichoderma* spp. – 70 and *Colletotrichum* spp. – 49 were obtained the most frequently. The other species of fungi, including *Rhizoctonia solani*, *Phoma* spp., and *Cylindrocarpon* sp. were isolated less frequently (tab. 3). In 2011 the presence of *Mycocentrospora acerina* spores was observed on annual plants. Some isolates of this fungus were obtained as a result of the mycological analysis of petioles and roots (tab. 3). Totally, 216 cultures of fungi belonging to eight species of genera *Alternaria* and *Fusarium* were obtained from annual plants in 2012 (tab. 3).

On the other hand, in 2012, 363 isolates belonging to 10 species were isolated during inflorescence time from biennial plants cultivated in the Świętokrzyskie province, and at the time of harvest 504 isolates belonging to 6 species were obtained (tabs 4, 5). Cultures of *Sclerotinia sclerotiorum* and *Botrytis cinerea* were isolated from these plants for the first time while the isolation of fungi from genera *Septoria*, *Colletotrichum*, *Rhizoctonia*, *Alternaria*, *Fusarium* and *Mycocentrospora* was repeated (tabs 4, 5).

In 2012, 235 cultures of fungi belonging to 9 species were obtained in Wojsławice from plants during flowering. During the harvest 482 isolates belonging to six species were isolated from plants (tabs 4, 5). Among these isolates *A. alternata, S. carvi* and *C. gloeosporioides* were isolated most frequently (tabs 4, 5).

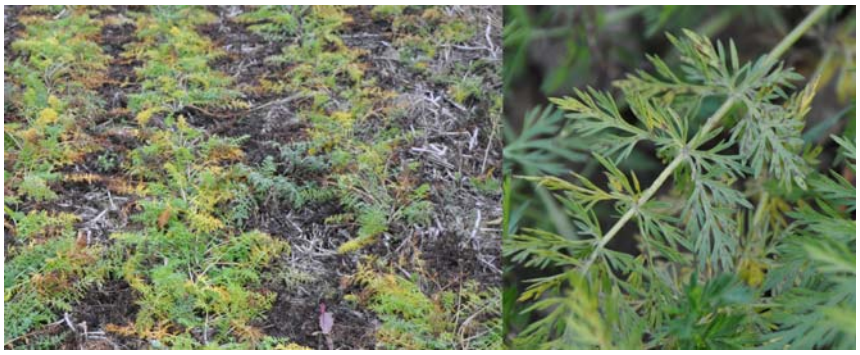

Fig. 1. Septoriosis of one-year-old plants of caraway (photo E. Zalewska)

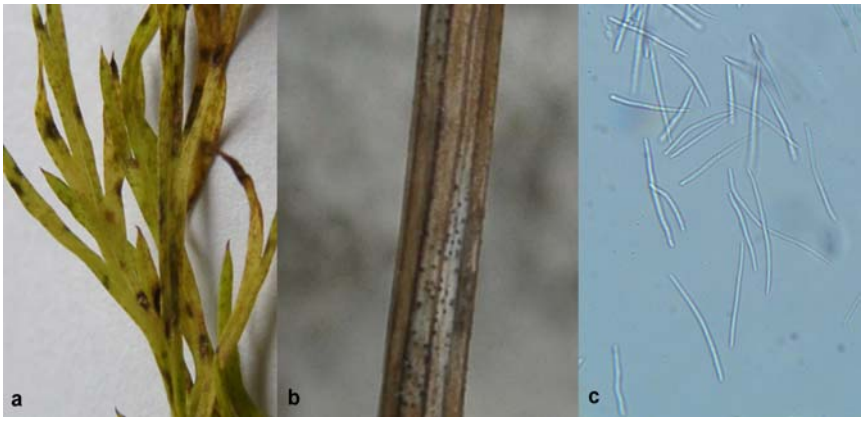

Fig. 2. *Septoria carvi*: a – spots on leaves, b – pycnidia on stem, c – conidia ×500 (photo E. Zalewska)

Fig. 3. Powdery mildew – *Erysiphe heraclei* on above-ground organs of caraway (photo E. Zalewska)

Fig. 4. *Erysiphe heraclei*: a – conidia × 250, b – cleistothecium ×120 (photo E. Zalewska)

Fig. 5. Symptoms of *Mycocentrospora acerina* on caraway (photo E. Zalewska)

Fig. 6. *Mycocentrospora acerina:* a – conidium, b – chlamydospores (photo E. Zalewska)

Table 3. Fungi isolated from annual plants of caraway (*Carum carvi* L.) in central Poland in the years 2011 and 2012

Fungi	Number of isolates								
	2011					2012			
	r	rc	l	p	total	r	l	p	total
Alternaria alternata (Fr.) Keissl.	10	4	37	16	67	6	27	12	45
Alternaria botrytis (Preuss) Woudenberg et Crous	2	9	2	12	25	11			11
Alternaria radicina Meier, Drechsler & E.D. Eddy							43	24	67
Boeremia exigua var. *exigua* (Desm.) Aveskamp, Gruyter & Verkley			6		6				
Chaetomium globosum Kunze	3				3				
Colletotrichum dematium (Pers.) Grove				26	26				
Colletotrichum gloeosporioides (Penz.) Penz. et Sacc.		6	17		23				
Cylindrocarpon didymum (Harting) Wollenw.		2	2		4				
Epicoccum nigrum Link.		2		5	7				
Fusarium oxysporum Schltdl.		3			3	10		2	12
Fusarium poae (Peck.) Wollenw.		2			2				
Fusarium sporotrichioides Sherb.	3	33			36	4	2	14	20
Gibberella avenacea R.J. Cook	14	74		6	94	2	7		9
Gibberella intricans Wollenw.	2	6			8		2		2
Haematonectria haematococca (Berk et Broome) Kunze				2	2	21		29	50
Mycocentrospora acerina (R. Hartig) Deighton	3			2	5				
Phoma spp.	2		8		10				
Rhizoctonia solani J.G. Kühn		25			25				
Septoria carvi Syd.			104	80	184				
Trichoderma aureoviride Rifai	31	7			38				
Trichoderma viride Pers.	29	3			32				
Total	99	176	176	149	600	54	81	81	216

r – roots, rc – root crown, l – leaves, p – petioles

Table 4. Fungi isolated from 2-year-old plants of caraway (*Carum carvi* L.) during flowering in the central and eastern region of Poland in the years 2012 and 2013

Fungi	Nnumber of isolates																				
	central region of Poland														east region of Poland						
	r		sb		st		u		l		p		total		r	sb	st	u	l	p	total
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	I	I	I	I	I	
Alternaria alternata (Fr.) Keissl.	9	8	12	4	1	4	13	5	72	30	59	29	166	80				6	46	18	70
Alternaria radicina Meier, Drechsler & E.D. Eddy							3		16				19								
Botrytis cinerea Pers.				8			9	3					9	11							
Cladosporium cladosporioides (Fresen.) G.A. de Vries						3	5	6		12		15	5	36							
Colletotrichum dematium (Pers.) Grove				2	2				14	8		13	16	23							
Colletotrichum gloeosporioides (Penz.) Penz. et Sacc.				3		2				12	7	19	7	36		6		2		3	11
Cylindrocarpon didymum (Harting) Wollenw.															4						4
Epicoccum nigrum Link.	3	2		3							3		6	5					2		2
Fusarium oxysporum Schltdl.		10		3										13							
Fusarium poae (Peck.) Wollenw.		4												4							
Fusarium sporotrichioides Sherb.		21		7		3						13		44	9						9
Gibberella avenacea R.J. Cook		6		2										8		26				3	29
Gibberella intricans Wollenw.																				3	3
Mycocentrospora acerina (R. Harting) Deighton	3	4		4		5	2	2		2	3	2	8	19							
Rhizoctonia solani J.G. Kühn	23	6	15										38	6	24	2		6			32
Sclerotinia sclerotiorum (Lib.) de Bary	3			12			4						7	12							
Septoria carvi Syd.			44				8	14	22	22	8	20	82	56			2	6	42	25	75
Total	41	61	71	48	3	17	44	30	124	86	80	111	363	353	37	34	2	20	90	52	235
Obligatory pathogens *Erysiphe heraclei* DC.					+	-	+	-	+	-	+										

+ – present
- – absent
r – roots , sb – stem base, st – stems , u – umbels, l – leaves, p – petioles
I – 2012, II – 2013

Table 5. Fungi isolated from 2-year-old plants of caraway (*Carum carvi* L.) during harvest in the central and eastern region of Poland in the years 2012 and 2013

Fungi	Number of isolates															
	central region of Poland										east region of Poland					
	st		l		u		s		total		st	l	p	u	s	total
	I	II	I	II	I	II	I	II	I	II						
Alternaria alternata (Fr.) Keissl.	96	92	89	92	118	112	91	141	394	437		2	7	50	100	159
Alternaria radicina Meier, Drechsler & E.D. Eddy	17	21	2	22	28	33	25	21	72	97						
Botrytis cinerea Pers.						5				5						
Cladosporium cladosporioides (Fresen.) G.A. de Vries		21		12		17		23		73						
Colletotrichum dematium (Pers.) Grove											4		2			6
Colletotrichum gloeosporioides (Penz.) Penz. et Sacc.											71	6	12	48		137
Cylindrocarpon didymum (Harting) Wollenw.		6								6	2	15	17			34
Epicoccum nigrum Link.		3					2		2	3			4	2		6
Fusarium sporotrichioides Sherb.		4	8	8		3			8	15						
Gibberella avenacea R.J. Cook			19	12			2		21	12						
Sclerotinia sclerotiorum (Lib.) de Bary		10								10						
Septoria carvi Syd.			7	20					7	20	22	71	47			140
Total	113	157	125	166	146	170	120	185	504	678	99	94	89	100	100	482

st – stems, l – leaves, p – petioles, u – umbels, s – schizocarps
I – 2012, II – 2013

In 2013, from biennial plants cultivated in Świętokrzyskie province respectively, 363 and 678 fungal cultures, belonging to 14 and 10 species of fungi were obtained during the flowering and harvest of caraway (tabs 4, 5). At the time of flowering the occurrence of *Mycocentrospora acerina* was repeated. This fungus inhabited the roots, stems, petioles, leaves and umbels. Yellow-orange, irregular spots from 3 to 7 mm in length were observed on the roots. On the above-ground parts of plants these spots were oblong, brown, darkening and linked with the time (fig. 5). Simultaneously, on the surface of the lesions there were acervuli, with thick salmon-pink drops of conidia (fig. 5) characteristic of genus *Mycocentrospora* (fig. 6a). Drops of secretion from acervuli dried up quickly in strong insolation. Several cultures of the fungus forming a characteristic brown mycelium, acervuli with conidia and chlamydospores were obtained from plants with these symptoms (fig. 6b).

The weather course during the research was variable and in some periods departed from the average perennial temperature (tabs 1, 2). In Świętokrzyskie province in the autumn, i.e. in September and October 2011, the temperature was quite high and it exceeded the average long-term values while in the second 10-days` period of October it was more than 20°C, in combination with a moderately high rainfall. In the eastern part of Poland the temperature was lower than in central Poland in the autumn. In the summer of 2012 the temperature in Świętokrzyskie province considerably exceeded the average long-term values with changeable periodically scanty rainfall (tabs 1, 2). On the other hand, in 2013 the average temperature in the summer months also exceeded the average long-term value both in the eastern area and the Świętokrzyskie region. However, in May and June 2013 in both regions of study rainfall exceeded the norm by over 100% (tabs 1, 2).

DISCUSSION

The qualitative and quantitative composition of fungi colonizing caraway plants differed depending on the years and regions of study. It was observed that the diversity of fungi species isolated from plants cultivated in central Poland was much greater than from plants in the eastern part of Poland, where the whole environmental conditions were less favorable for the development of both pathogens and plants. This is indicated by delayed caraway vegetation at least by about two weeks in the eastern region in comparison with the development of plants in central Poland. Although mycosis have been studied in south-eastern Poland since 2001 [Machowicz-Stefaniak and Zalewska 2004, 2008] a new species *Mycocentrospora acerina*, not previously recorded on caraway in Poland, has been found only recently. This fungus has a wide range of host plants, including plants of the family *Umbelliferae,* i.e. carrots, parsnips, celery and weeds [Day et al. 1972, Davies et al. 1981, Evenhuis and Verdam 1995, Evenhuis 1998]. The harmfulness of this fungus to the roots and above-ground parts of caraway in the Netherlands was shown by Evenhuis [1998]. Current research indicates that it can infect plants in the first year of cultivation and biennial plants, and its harmfulness results from causing brown, blackening lesions on the infected organs.

Isolation of the fungus, for example from the roots and umbels suggests that the soil and caraway seeds can be a source of inoculum of *M. acerina* [Evenhuis 1998]. Since

the sporulation of the fungus is stimulated by rainfall and moderately high temperature, i.e. about 15°C [Evenhuis 1998], it can be highly harmful to caraway in the temperate climate. The threat of caraway by *M. acerina* in the Polish conditions is all the more likely that the occurrence of the pathogen was repeated in the years of research. On the other hand, abundant secretion of conidia from acervuli found directly on the plants indicates that the climatic conditions in Poland are favorable for the development of *M. acerina* and the formation of a secondary source of infection.

Septoria carvi is another dangerous pathogen of caraway, which in varying severity occurred on the above-ground parts of plants growing in both regions. The presence of this fungus causing caraway septoriosis was found for the first time in Poland in 2001 [Zalewska and Machowicz-Stefaniak 2003]. In warm and humid growing seasons it occurs epidemically causing great losses in plant crops [Machowicz-Stefaniak and Zalewska 2008, Zalewska 2012]. In the present study the innovative element shown in the development of *S. carvi* was the abundant occurrence and development of the pathogen on plants in late autumn. This resulted in an early appearance of the disease in the next period of vegetation. The development of septoriosis in the autumn, detected for the first time, was a consequence of rapid and persistent warming, which activated the development of not only *S. carvi* mycelium but also the intense formation of pycnidia and cirri of spores of fungus recognized earlier as a thermophile species [Zalewska 2012].

Another, phenomenon observed for the first time on caraway plantations in central Poland, was the development of powdery mildew epidemics – *Erysiphe heraclei*. The massive presence of this fungus in the period of flowering and harvesting during the warmest and moderately moist growing season of 2012 confirms the high thermal requirements of the fungus, i.e. the optimum from 20 to 28°C and relative humidity from 75 to 100% [Kryczyński and Weber 2010]. It seems that the mycelium covering almost the entire surface of caraway plants in addition to the conidial and perfect stage of *E. heraclei* prevented the infection of plants and the development of other fungi species. This is indicated by low diversity of fungi species inhabiting caraway plants in 2012.

The results of the present study indicated that the climatic conditions in the eastern region of the country were not favorable to the occurrence and development of the obligatory parasite *E. heraclei*. On the other hand, the development of thermophile species *S. carvi* on crops in the eastern region was delayed comparing with the central region of Poland. Although pycnidia of *S. carvi* were found on the plants, the formation of conidia was so weak that the secretion of conidia was not observed, which limited the possibility of the pathogen spread.

Colonization of the roots, the root crown of seedlings or the base of the caraway stem by *Rhizoctonia solani* in both region of cultivation and in the central part of Poland also by *Sclerotinia sclerotiorum* should be considered as dangerous for plants. These fungi are known as polyphagic plant pathogens, surviving in the soil environment [Sesan1998, Marcinkowska 2012]. Their presence on the caraway is associated with frequent cultivation of host plants on the same field and easy survival of these pathogens in the form of saprophytic mycelium and sclerotia, which are the most stable form of fungi development [Sesan 1998, Machowicz-Stefaniak and Zalewska 2008].

Similarly, frequent colonization of caraway, especially the organs in contact with the soil, by the numerous species of genus *Fusarium*, indicates a lack of proper crop rota-

tion and accumulation of propagation forms of *Fusarium* spp.in the soil [Reuveni 1982, Łacicowa and and Machowicz-Stefaniak 1983, Papas and Elena 1997, Zalewska and Machowicz-Stefaniak 2004]. Moreover, it was found that *Colletotrichum dematium* and *C. gloeosporioides* [Zalewska 2010, Machowicz-Stefaniak et al. 2011], the fungi pathogenic to caraway and other plants of the family *Apiaceae*, occurred on the above-ground parts of plants cultivated in both regions. *Colletotrichum dematium*, detected for the first time in Poland on caraway in 2005 [Machowicz-Stefaniak 2010], and *C. gloeosporioides,* isolated in the years 2001–2010 [Machowicz-Stefaniak et al. 2011], are still present in the populations of phyllosphere microorganisms of caraway. It was observed during the study that there was an increasing threat of caraway, as compared to the previous years, by these dangerous pathogens causing anthracnose of plants [Gärber and Schrenk 2001, Jeske 2006, Zalewska 2010, Machowicz-Stefaniak et al. 2011].

In both regions of cultivation and on all parts of caraway the fungus *Alternaria alternata* occurred commonly, and in smaller numbers *A. radicina*, like in previous years [Machowicz-Stefaniak and Zalewska 2004, 2008]. Due to their strong toxinogenic properties these fungi reduce the quality of the herbal material [Machowicz-Stefaniak and Zalewska 2008]. The other species of genera *Botrytis*, *Boeremia*, *Cladosporium*, *Chaetomium* and *Cylindrocarpon* rarely occurred on plants and only in some years.

Beneficial fungi from genera *Trichoderma* and *Epicoccum* had a very small share in the composition of fungi species colonizing caraway [Machowicz-Stefaniak et al. 2008].

CONCLUSIONS

1. Plants of caraway may be inhabited by numerous fungi species surviving in the soil, seeds or in biennial plants.
2. The severity and range of the occurrence of pathogens are limited by changing environmental conditions.
3. Warm and humid growing seasons did not only stimulate the development of *Septoria carvi* but also contributed to a changes cycle of the development of the fungus.
4. The epidemic of powdery mildew of caraway is possible during prolonged periods of high temperatures, and scarce rainfall.
5. An increasing threat for caraway cultivated in Poland is observed by fungi of genus *Colletotrichum*, causing anthracnose of plants.
6. A new threat to caraway is the dangerous pathogen *Mycocentrospora acerina*, detected in Poland for the first time as a result of the present study.

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GRZYBY ZASIEDLAJĄCE KMINEK ZWYCZAJNY W RÓŻNYCH REGIONACH UPRAWY

Streszczenie. Powtarzająca się w tych samych regionach rolniczych uprawa kminku zwyczajnego sprzyja występowaniu chorób infekcyjnych, które obniżają ilość i jakość surowca zielarskiego. Celem badań było określenie składu gatunkowego grzybów zasiedlających różne organy kminku odmiany Konczewicki, w latach 2011–2013. Obserwacje zdrowotności roślin prowadzono na plantacjach w regionie centralnej i wschodniej Polski. Czyste kultury grzybów identyfikowano z dobrym skutkiem na PDA lub na podłożach standardowych. Wykryto nowy, nienotowany wcześniej na kminku w Polsce grzyb *Mycocentrospora acerina*, powodujący nekrotyczne plamy na nadziemnych i podziemnych częściach roślin. W regionie centralnej Polski podczas ciepłej i wilgotnej pogody występowała epidemia seproriozy kminku *Septoria carvi*. Przy temperaturze dochodzącej do 28^{o}C i niewielkiej wilgotności względnej powietrza wystąpiła epidemia mączniaka właściwego *Erysiphe heraclei*. Wykazano rosnące zagrożenie kminku przez grzyby *Colletotrichum* spp. powodujące antraknozy oraz przez grzyby glebowe, *Sclerotinia sclerotiorum* i *Rhizoctonia solani*.

Słowa kluczowe: kminek zwyczajny, zdrowotność roślin, grzyby, hodowla, identyfikacja

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