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OCCURRENCE OF SUGAR BEET ROOT ROT (*APHANOMYCES COCHLIOIDES*) IN POLAND

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Abstract

Symptoms of the root rot on sugar beet have been observed in Poland since 2002. The causal agent of the disease was *Aphanomyces cochlioides*. Typical symptoms of the disease occurred mainly on the upper part of the root. The root surface became distorted, cracked and constricted below the crown. Light-brown or brown to black water-soaked lesions occurred occasionally. The symptoms of girth-scab developed in many cases in the beginning of the disease. The disease was promoted by rainy and hot weather and developed during summer until harvest. The intensity of infestation was minute to very severe and depended on weather conditions, sugar beet cultivar, field and crop rotation.

Key words: *Aphanomyces cochlioides*, sugar beet

Introduction

In 2001 and 2002 severe losses of sugar beet roots yield were observed in Poland and Germany (Piszczek 2002, 2004, Petersen and Schlinker 2003). The main pathogen causing root disease was *Aphanomyces cochlioides* although the streptomycetes were also suspected (Petersen and Schlinker 2003). *Aphanomyces cochlioides* was not identified as a pathogen of the mature sugar beet roots before 2001. Earlier the pathogen was known in Poland only as a cause of seedling damping-off and young plant disease (Szymczak-Nowak 1987). Aphanomyces root rot was observed over a large area in Great Britain and Belgium in the end of the XX century (Asher 1992, Francis 2003).

Aphanomyces cochlioides can infect roots all over summer but the disease develops during periods of warm and wet conditions (Asher 1992, Harveson et al. 2002,

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Dyer et al. 2004, Windels 2000). The pathogen is common in the fields, most often in those with acidic soils (Asher 1992, Payne et al. 1994). Oospores formed in diseased tissues of sugar beets can persist in soil for many years (Dyer et al. 2004), so it is important to control it by using partially resistant or at least not highly susceptible cultivars.

The aim of the work was to estimate the problem with sugar beet root rot overall, the role of *A. cochlioides* as a cause of root rot and to estimate some cultivars susceptibility to infection.

Materials and methods

Field experiments were carried out on fields in South Poland. Disease symptoms were evaluated on sugar beet roots during 2002–2007, in approximately 1–1.5 month intervals, three or four times each year. Table 1 shows the number of sugar beet cultivars and breeding lines estimated during the harvest time (October) on differently localized fields. A minimum of approximately 35 to 133 roots were estimated every time for different cultivars of sugar beet in each replication. Three to four replications were used.

The health condition of roots was estimated with two types of scale. A 9-degree scale I was given by Piszczek (2002, 2004): 9 – a healthy root and 1– a completely rotten root. The 5-degree scale II was worked out by Moliszewska for commercial use by sugar factory workers.

Table 1

Locations of fields

Year	Estimated by scale I		Estimated by scale II	
	number of cultivars	location	number of cultivars	location
2002	12	Tłubice	–	–
	12	Kowal	–	–
2003	12	Komorowo	20	Garbów
	12	Wróblewo	20	Łubna
	12	Ogorzelice	–	–
2004	12	Pelplin	22	Urbanowice
	12	Łówkowice	22	Łubna
	18	Koniczynka 1	–	–
	18	Koniczynka 2	–	–
	18	Piwnice	–	–
2005	12	Bielsk	13	Śmiłów*
	12	Kołaki	–	–
	12	Krępa	–	–
2006	12	Baboszewo	22	Śmiłów*
	24	Ruszkowo	–	–
2007	–	–	31	Śmiłów*

*Sugar beet was the forecrop.

Scale II:

0 – healthy root, no spots or symptoms of "scab",

1 – low infection, less than 15% of the root surface with spots of "scab" or rot,

2 – medium infection, 15–30% of root surface damaged,

3 – high infection, 30–70% of the root surface damaged, rotted spots, rotted tissues inside the root,

4 – more than 70% of the root surface diseased, visible spots of rotted tissue, root damaged or dead plant; roots estimated in this degree gave no yield.

According to the scales infection coefficients (Ip) were calculated, with a formula given by Burgieł (1980).

For pathogen detection in diseased tissues routine phytopathological methods were used (Moliszewska 2000, Windels 2000, Schaad et al. 2001, Piszczek 2004). *Aphanomyces cochlioides* was identified additionally in water cultures (Windels 2000).

Results

The estimation of *A. cochlioides* infestation was performed in the field basing on typical and distinct symptoms of the disease. Diseased roots became distorted, cracked and constricted below the crown, frequently with light-brown or brown to black water-soaked rotten tissues. These symptoms were not observed regularly in the experimental fields. In the fields estimated by scale I the infection coefficients for "Aphanomyces" symptoms were 0.2% in 2005 to 6.1% in 2004 (Fig. 1). In 2003

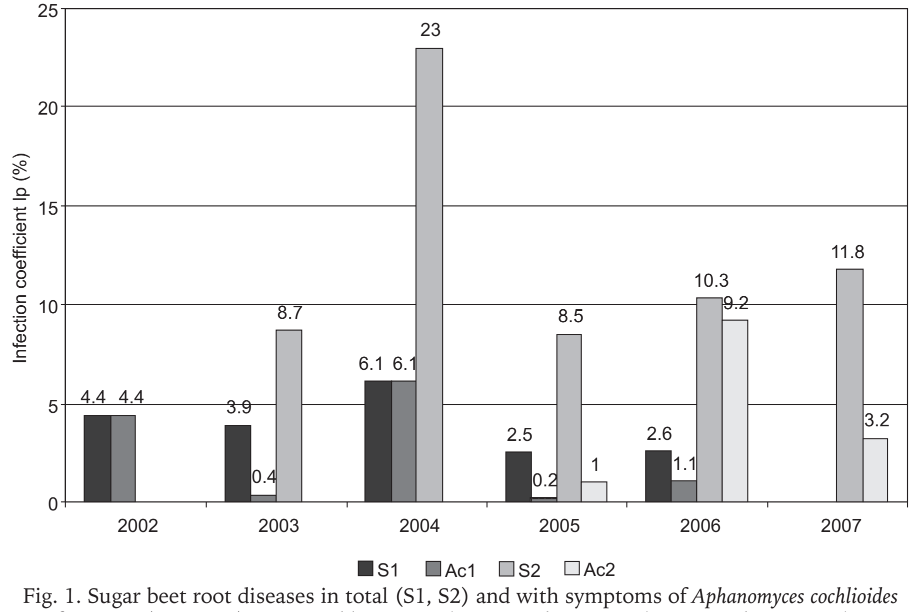

Fig. 1. Sugar beet root diseases in total (S1, S2) and with symptoms of *Aphanomyces cochlioides* infestation (Ac1, Ac2) estimated by two scales: S1 and Ac1 – scale I, S2 and Ac2 – scale II; estimation by scale I was not done in 2007 and by scale II was not done in 2002

to 2004 typical *A. cochlioides* symptoms were not identified in the fields where the scale II was used, and the highest infection coefficient (9.2%) was found in 2006 (Fig. 1). In 2002 and 2004 all observed symptoms of root injury and evaluated by scale I were recognized as "Aphanomyces". Similar results were obtained in the experimental fields evaluated by scale II in 2006 (Fig. 1). The experiments estimated by scale II were carried out in the fields with sugar beet as the forecrop (Table 1). The differences between field results obtained in different years depended on weather conditions, crop rotation and the disease development. Especially the latter factor had a great importance because probably some symptoms were not recognized as typical of *A. cochlioides*, although the pathogen was isolated in the laboratory (Fig. 1, Table 4). In Poland severe infestation was observed in 2001 and 2002, which were years with high precipitation (Table 2) but in 2003–2007 the precipitation in July was not so high, although the temperature was conductive to disease development. Under those conditions the disease was not severe, as it was the case in 2001–2002 (Tables 2 and 3, Fig. 1).

Table 2

Average total precipitation in South Poland in 2001–2007 (mm)
(courtesy of Südzucker Polska)

Month	2001	2002	2003	2004	2004	2005	2006	2007
	Śmiłów				Urbanowice	Śmiłów		
V	44.0	43.2	83.0	40.7	48.7	68.2	57.1	42.0
VI	78.4	71.1	73.0	58.0	110.2	32.2	71.4	56.0
VII	161.0	98.1	49.7	97.6	50.0	61.7	0.5	89.0
VIII	65.1	39.6	20.9	46.2	70.0	33.6	110.2	63.0
Total V–VIII	348.5	252.0	226.6	242.5	278.9	127.5	239.2	250.0

Laboratory investigations carried out in 2002, revealed structures of *A. cochlioides* in 48% of rotten roots. Simultaneously, on some plants *Pythium* sp. (26%) and *Rhizoctonia solani* (12%) were found (Piszczek 2004).

In 2003 *A. cochlioides* was isolated from 59.3% of rotten roots in Komorowo, Wróblewo and Ogorzelice. In the same fields *R. solani* was isolated only from 7.4% of roots. In the field from Łubna there was only 4% of *A. cochlioides* between the microorganisms found on diseased roots. The pathogen was not found on roots harvested in Garbów (Table 4).

In 2004 in Łubna *A. cochlioides* made up 4.4% of microorganisms isolated from roots, *P. ultimum* – 4.2% and *Rhizoctonia* spp. – 6.7%. *Rhizoctonia* spp. made up 55.8% of microorganisms obtained from roots in Urbanowice, where *A. cochlioides* was not found (Table 4).

In rotten tissues of roots from Śmiłów, in 2005, 7% of microorganisms represented *A. cochlioides* and 9.5% – *P. ultimum*. Next year (2006) in the same field *A. cochlioides* was isolated from 49.7% of the diseased roots and *P. ultimum* from 10.2%. In 2007 *A. cochlioides* isolates consisted 44.7% of fungi and oomycetes obtained from rotten tissues (Table 4). In 2003 and 2004 Actinomycetales were addi-

Table 3

Temperatures in South Poland in 2003–2007 (°C)
(courtesy of Südzucker Polska)

Location and year		V	VI	VII	VIII
Łubna 2003	Min.	6	9	12	11
	Max.	31	33	34	33
	Av.	18	21	22	21
Łubna 2004	Min.	2	8	11	9
	Max.	27	30	31	34
	Av.	15	18	20	19
Urbanowice 2004	Min.	5.4	9.6	11.2	11.1
	Max.	18.2	21.7	24.2	25.7
Śmiłów 2005	Max.	33	31	36	29
Sandomierz 2006	Min.	0	6	10	10
	Max.	31	28	35	29
	Av.	12.3	15.2	19.6	18.1
Śmiłów 2007	Min.	10.5	15.6	14.5	12.8
	Max.	21.9	25.8	25.3	25.5
	Av.	16.2	20.7	19.9	19.1

Table 4

Main groups of pathogens isolated from diseased sugar beet root tissues
(% of total investigated fragments)

Pathogen	2003		2004		2005	2006	2007
	Garbów	Łubna	Urbanowice	Łubna	Śmiłów	Śmiłów	Śmiłów
Aphanomyces cochlioides	–	4	–	4.4	4.9	49.7	44.7
Fusarium oxysporum	82	68	13.3	62.7	66.7	21.4	27.1
Fusarium solani	27	39	6.7	11.8	63.3	58.7	77.0
Fusarium spp.	30	37	120.9	6.7	10.8	4.9	6.7
Rhizoctonia spp.	–	–	55.8	6.7	–	–	–
Pythium ultimum	–	–	–	4.2	9.5	10.2	–

tionally isolated from the diseased roots from Garbów, Łubna and Urbanowice. *Streptomyces scabies* was not found, although typical symptoms of scab were present on roots.

Some cultivars of sugar beet were more susceptible to infections by *A. cochlioides*. It seems, however, that the properties strongly depend on weather conditions as well as on crop rotation (Table 5), as the disease symptoms can be observed only under favourable conditions. The cultivars 'Arthur', 'Cartouche',

Table 5

Health condition of sugar beet roots depending on crop rotation in Koniczynka (estimation prepared according to scale I)

Health condition	Year	Crop rotation (%)			LSD	
		2-years*	3-years*	4-years*	0.01	0.02
Roots without symptoms	2003 2004	50.0 58.4	62.0 43.6	70.0 73.6	6.6 –	– 16.37
"Scab" symptoms – infection coefficient (Ip)	2003 2004	6.3 1.7	2.8 –	5.1 2.5	1.2 –	– 0.35
Aphanomyces cochlioides symptoms – infection coefficient (Ip)	2003 2004	3.1 1.2	4.1 –	1.6 2.7	– –	1.5 0.78

*Sugar beet was cultivated, adequately, in the second (one year break), third and fourth year of the crop rotation.

'Gesina', 'Poljana', 'Canasta', 'Lupus', 'Samuraj', 'Jambus' and 'Lubelska' are more susceptible to *A. cochlioides*. Cultivars 'Boryna', 'Canyon', 'Gryf', 'Soplica', 'Lubelska', 'Prince' and 'Zawisza' showed greater frequency of total symptoms of root diseases, especially of scab, which was the most frequent type of symptoms observed in the field.

The results of our investigations confirmed the information that shortened crop rotation is conductive to increase the "Aphanomyces" symptoms observed in the field, although more important is the fact that the highest number of healthy roots can be achieved with not less than four-year-long crop rotation (Table 5). Isolations of *A. cochlioides* performed in the experiments carried out in Śmiłów showed a great increase of the pathogen frequency in rotten root tissues, if the precrop was sugar beet (Table 4).

Discussion

The occurrence of *A. cochlioides* strongly depends on weather conditions. Fairly high air temperature and moist soil is needed for its development (Asher 1992, Williams and Asher 1996, Windels 2000, Harveson et al. 2002, Dyer et al. 2004). Essential for *A. cochlioides* is the rainfall in June and especially in July but the individual susceptibility of cultivars plays also an important role in the disease development. The occurrence of the pathogen in 2002 was the result of favourable weather conditions in the previous year (Table 2, Windels and Lamey 1998). Piszczek (2002, 2004) reported that in 2001 very high root rot frequency due to *A. cochlioides* infections was observed. The increase of pathogen population in 2001 resulted in high infection level in 2002. Symptoms of *A. cochlioides* injury were not well recognized in Poland, so there was a demand of additional investigations.

Aphanomyces cochlioides is rather difficult to detect in rotten tissue (Beale et al. 2002). Sometimes it was not isolated from the diseased tissues even when the symptoms described before were very distinct. Probably one of the reasons can be bacteria and fungi living in the rotten tissues, especially *Fusarium* spp. (Table 4, Windels 2000). Laboratory observations do not fully confirm this information, because hyphae of *A. cochlioides* can grow quite well between other hyphae in water culture.

Difficulties and differences in *A. cochlioides* occurrence in the field and in detection in laboratory can give an erroneous outlook for the disease, so the distinct description of symptoms is necessary for practice. Although scab symptoms can not be recognized as "Aphanomyces", they seem to be essential for the disease development. The results of this work suggest at least two types of root injury symptoms: first type – "scab" together with other symptoms in total, second type – typical "Aphanomyces" symptoms. "Scab" symptoms are very common on sugar beet roots in all fields and it seems that frequently they are not harmful to the yield if the injury is limited to the surface of the root only. The "scab" symptoms can develop into the dry rot or wet rot caused by *A. cochlioides*. Some initial symptoms of *A. cochlioides* infestation resemble scab.

Under field conditions two types of scales for root estimation were used. Scale I consisting of 9-degrees is more precise, but the precision is important only for scientific and laboratory considerations. In practice the scale is difficult to use for people working in sugar factories. In fact, degrees 5 and 4 in scale I describe roots with very limited yield – over 50% of all root surface injured and rot inside the root. Roots of this kind do not build up the sugar beet yield. These two degrees (5 and 4) correspond to degrees 3 and 4 in the second scale (II). Other degrees (3–1) in scale I characterize plants with different extent of rot. Calculation of infection coefficients for the results of both scales gives different results, usually the coefficient value is lower for scale I. The result also depends on estimation of roots classified in scale I as 6, which in scale II can be classified as 2 or 3. Scale II gives higher infection coefficient values, because in this case all sugar beet roots damaged to high degree are classified as the same degree – 4. The shorter scale can be used easier by different persons, so it can be recommended mostly for other than scientific purposes.

The incidence of *A. cochlioides* infection differs according to crop rotation (Persson and Olsson 2005). The results of our investigations confirmed that reduced crop rotation is conductive to the "Aphanomyces" symptoms observed in the field (Table 5). The time can allow to avoid *A. cochlioides* (Payne et al. 1994) and other sugar beets pathogens because the soil environment posses the individual and natural possibility to delimit population of *A. cochlioides*. As Szymczak-Nowak (1987) proved, even when soil free of *A. cochlioides* was artificially infested with the pathogen, the occurrence of sugar beets damping-off was very low. Windels and Lamey (1998) emphasize that the field history – climate and crop, are important for planning sugar beet production. The thesis is also confirmed by our investigations.

Conclusions

1. Aphanomyces root rot occurs on sugar beet during the whole season and causes two types of symptoms – similar to scab and typical of Aphanomyces rot.
2. *Pythium* spp. can occur together with *A. cochlioides* in rotten roots.
3. Cultivars differ in their susceptibility to *A. cochlioides*.
4. Scale given by Moliszewska (scale II) is usefull for field investigation and sugar factory use, while the scale given by Piszczek (scale I) can be recommended for laboratory use.
5. Short field rotation can stimulate the occurrence of sugar beet root rot.

Streszczenie

WYSTĘPOWANIE ZGNILIZNY KORZENI BURAKA CUKROWEGO (*APHANOMYCES COCHLIOIDES*) W POLSCE

Począwszy od 2002 roku obserwowano w Polsce symptomy zgnilizny korzeni buraka cukrowego powodowane porażeniami przez *Aphanomyces cochlioides*. Wcześniej gatunek *A. cochlioides* był znany w Polsce jako sprawca zgorzeli siewek buraka i patogen porażający sporadycznie młode rośliny. Nie opisywano zgnilizn występujących na korzeniach w późniejszych fazach rozwojowych. Typowe objawy gnicia korzeni obejmują szereg zjawisk: od zniekształcenia, pofałdowania i spękania powierzchni korzeni po zgnilizny mniej lub bardziej sięgające w głąb tkanek. Początkowy obraz choroby często obejmuje zniszczenie tkanki okrywającej przypominające uszkodzenia określane mianem parcha. Podobne objawy zaobserwowano w Europie w latach dziewięćdziesiątych XX wieku, najpierw w Wielkiej Brytanii oraz w Belgii. Nasileniu późnych form porażenia przez *A. cochlioides* towarzyszyły sprzyjające warunki atmosferyczne: obfite opady oraz wysoka temperatura powietrza, szczególnie w czerwcu i lipcu. Takie warunki pogodowe występowały w Polsce począwszy od 2002 roku. Skutkowało to przedłużeniem aktywności *A. cochlioides* na późniejsze fazy rozwoju korzeni buraka cukrowego. Intensywność porażeń zależała nie tylko od warunków atmosferycznych, choć wydaje się, że one były głównym czynnikiem warunkującym rozwój choroby, ale także od odmiany, stanowiska i długości płodozmianu. Nasilenie porażeń przez *A. cochlioides* w zależności od tych czynników zmieniało się od znikomego do bardzo znaczącego, sięgającego nawet kilkudziesięciu procent. Obserwowano różną intensywność występowania choroby w poszczególnych latach prowadzenia badań, a zależała ona także od rejonizacji uprawy.

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