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# HARMFULNESS OF SOIL-BORNE FUNGI TOWARDS ROOT CHICORY (*Cichorium intybus* L. var. *sativum* Bisch.) CULTIVATED WITH THE USE OF COVER CROPS

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**Abstract.** Chicory is a herbaceans plant, belonging to the family of Asteracae. This plant is a rich source of polysaccharides, vitamins, acids and mineral salts. The studies concerned the harmfulness of soil-borne fungi towards root chicory – a high-inulin plant, with considerable pro-health values – cultivated with the use of such cover crops as oats, tansy phacelia and spring vetch. Among the mulching plants, oats had the most positive effect on the number and healthiness of the seedlings and roots of chicory. The most harmful towards the seedlings proved to be the following: *Altenaria alternata, A. cichorii, Fusarium oxysporum, Pythium irregulare, Rhizoctonia solani* and *Sclerotinia sclerotiorum.* The roots of older chicory plants were also infected by *A. tenuissima, Botrytis cinerea, F. culmorum, F. solani, Phoma cichoracearum, Phytophthora* sp., *Ramularia cichorii, Sclerotium rolfsii, Thielaviopsis basicola* and *Verticilium dahliae.*

**Key words:** oat, tansy phacelia, spring vetch, mulch, chicory phytopathogens

## INTRODUCTION

Chicory (*Cichorium intybus* L.) is a herbaceans plant, belonging to the family of Asteracae [Mirek et al. 1997]. It includes about 10 species, growing in moderately warm zones of Europe, Asia and Africa [Poli et al. 2002, Barcaccia et al. 2003, Geldenhuis et al. 2006]. In many regions of the world it is cultivated or running wild. In Poland, on the other hand, chicory is little known and rarely cultivated. In the first year of cultivation, it forms a rosette of leaves and a thickened root, while in the second – an inflorescence branch and the seeds [Poli et al. 2002]. There are a lot of cultivars of this plant known in the world, whereas in our country mainly a leaf chicory (*Cichorium intybus* L. var. *foliosum* Bisch.) and a root chicory (*Cichorium intybus* L. var. *sativum* Bisch.) are culti-

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vated [Barcaccia et al. 2003, Rożek 2004]. This plant is a rich source of polysaccharides (intibin and inulin), vitamins ($B_1$, $B_2$, C), acids (nicotinic, valeric, oxalic acids) and mineral salts (magnesium, potassium, sodium, phosphorus, copper, zinc, iron) [Poli et al. 2002, Koo-HyunNa et al. 2003]. It contains considerable quantities of inulin – a glycoside which has a positive influence on *Lactobacillus* sp. and *Bifidobacterium* sp. [Kleessen et al. 1997, Koo-HyunNa et al. 2003]. It can be used in the prophylaxy and treatment of diseases of the digestive system, blood circulation and diabetes. It has a positive effect on kidneys and liver as well as inhibiting cancerous processes [Koo-HyunNa et al. 2003]. Dried roots of *Cichorium intybus* var. *sativum* is also used in the production of coffee and carbohydrate preparations [Baert et al. 1992].

Nowadays studies concentrate on searching for new technologies of cultivating different plant species, including the root plants, with the aim of improving the size and quality of their yield. Both in integrated and ecological farming the so-called cover crops used as mulch acquire special importance [Abdul-Baki et al. 2002, Błażewicz-Woźniak 2005, Patkowska and Konopiński 2008a, 2011]. Plant mulch affects the physical properties of the soil, the economy of the organic substance and mineral elements, weed infestation, microbiological activity of the soil and plant healthiness [Leary and DeFrank 2000, Błażewicz-Woźniak 2005, Pięta and Kęsik 2007, Błażewicz-Woźniak and Konopiński 2011]. Cover crops also improve the phytosanitary condition of the soil and decrease plant infection by soil-borne fungi [Oktaba 1987, Jamiołkowska 2007, Pastucha and Kołodziej 2007, Pięta and Kęsik 2007, Patkowska and Konopiński 2008a, 2011].

Information is accessible in the literature mainly concerning the pathogens of leaf chicory. As reported by Golden [1984], Schober and Vermeulen [1999], Schober and Zadoks [1999], Tran-Nguyen et al. [2003] and Koike and Bull [2006], different cultivars of *Cichorum intybus* var. *foliosum* can be infected by phytoplasms (16SrII-E group) or bacteria (*Pectobacterium carotovorum* subsp. *carotovorum* (Jones) Hauben, *Pseudomonas cichorii* (Swingle) Stapp., *Pseudomonas marginalis* (Brown) Stevens). The cultivation of this plant is also threatened by the following fungi: *Altenaria cichorii* Nattrass, *Phytophthora cryptogea* (Pethyb. and Laff.), *Pythium mastophorum* (Drechs.) and *Sclerotinia sclerotiorum* (Lib.) de Bary [Plentinger et al. 2000, Lima et al. 2003, Sanvincente et al. 2003, Jonghe et al. 2005, Benigni and Bompeix 2006].

The main purpose of the cultivation should be to seek such methods that inhibit the infection of root chicory plants by soil-borne plant pathogens. That is the reason why the authors undertook the studies signalled in the title.

## MATERIAL AND METHODS

**Field experiment.** The object of the studies conducted in the years 2006–2007 were the plants of root chicory cv. 'Polanowicka', cultivated at the Experimental Farm of Felin, belonging to the University of Life Science in Lublin. The experimental plots were established on grey brown podzolic soil formed from loesses lying on chalky clays, with the mechanical composition corresponding to silty medium loam. The field experiment considered soil mulching with cover crops such as oats (*Avena sativa* L.), tansy phacelia (*Phacelia tanacetifolia* B.) and spring vetch (*Vicia sativa* L.).

Chicory was sown in the first 10 days of May, while cover crops were sown in the first half of August of each year preceding the establishment of the experiment. Oats, tansy phacelia and spring vetch produced abundant green mass before winter and it was a natural mulch of the surface of the plough land which was managed in a twofold way: 1) mixed with the soil as a result of spring ploughing, or 2) mixed with the soil as a result of pre-winter ploughing. The conventional cultivation of chicory, i.e. without cover crops, constituted the control. The experiment was set up in a split-plots scheme in four repetitions. The area of each plot was 15 $m^2$. Meteorological data from the region of studies were analyzed on the basis of information obtained from the Chair of Meteorology of the University of Life Science in Lublin.

**Laboratory mycological analysis.** In each year of studies, the number and healthiness of chicory seedlings were established. 10 seedlings with disease symptoms were sampled from particular experimental combinations with the aim of conducting the mycological analysis of the infected roots. Besides, after the harvest (the second 10-days' period of October), 10 roots with necrotic signs chosen at random from each experimental combination were submitted to the mycological analysis. The mycological analysis was conducted according to the method described by Patkowska and Konopiński [2011]. The infected parts of plants were rinsed for 30 minutes under running tap water, after which they were disinfected in 0.1% sodium hypochlorite. The plant material disinfected on the surface was rinsed three times in sterile distilled water, 3 minutes in each. 3-milimetre fragments were made from so prepared plant material and 10 of them were put on each of the Petri dishes on solidified mineral medium with the following composition: 38 g saccharose, 0.7 g $NH_4NO_3$, 0.3 g $KH_2PO_4$, 0.3 g $MgSO_4 \times 7H_2O$, 20 g agar and trace quantities of $FeCl_3 \times 6\ H_2O$, $ZnSO_4 \times 7\ H_2O$, $CuSO_4 \times 7\ H_2O$ and $MnSO_4 \times 5\ H_2O$. The whole was filled up with distilled water up to 1000 ml and was sterilized in an autoclave for 20 minutes at the temperature of 121°C under the pressure of 1 atmosphere. 100 fragments of infected seedling roots and plants after the harvest were examined for each of the experimental combinations.

The dishes together with the plant material on them were incubated in a thermostat for 7 days at the temperature of 23°C, after which time fungi colonies grown around the infected plant fragments were taken to test tubes for slants with maltose medium (a ready-made product by bio Merieux company). The isolated fungi were marked for the species, using the keys and monographic records [De Vries 1952, Gilman 1957, Barnett 1960, Raper et al. 1968, Rifai 1969, Domsch and Gams 1970, Booth 1971, Ellis 1976, Sałata and Rudnicka-Jezierska 1979, Ramirez 1982, Nelson et al. 1983].

The mycological analysis made it possible to establish the quantitative and qualitative composition of fungi infecting the underground parts of chicory.

Results concerning the emergences and healthiness of chicory seedlings were statistically analyzed using variance analysis. The significance of differences between the means was established using Tukey's confidence intervals [Oktaba 1987]. Statistical calculations were carried out using Statistica program, version 7.1.

## RESULTS AND DISCUSSION

**Field experiment.** Considering thermal conditions, the year 2006 was a period conducive to the emergencies of chicory plants. The mean temperature in May was higher by 0.6°C than the mean value of many years. Successive months, until the harvest, were also characterized by higher temperatures than the mean temperatures of many years, in June by 0.4°C, in July by 4.0°C, in August by 0.1°C, in September by 2.8°C, and in October by 2.2°C (tab. 1).

Table 1. Meteorological data for the period May – October of 2006 and 2007 as compared to the mean from the period 1963–1992

| Month | Mean from the period 1963–1992 | | Difference of mean temperature in comparison with long-term period | | Percentage of the average annual rainfalls | |
|---|---|---|---|---|---|---|
| | mean temp. (°C) | precipitation total (mm) | 2006 | 2007 | 2006 | 2007 |
| May | 13.0 | 58.3 | +0.6 | +2.0 | 102.0 | 139.8 |
| June | 16.5 | 65.8 | +0.4 | +1.6 | 57.6 | 133.4 |
| July | 17.9 | 78.0 | +4.0 | +1.3 | 8.7 | 115.4 |
| August | 17.3 | 69.7 | +0.1 | +1.1 | 284.5 | 53.9 |
| September | 12.9 | 52.1 | +2.8 | +0.1 | 21.1 | 249.1 |
| October | 7.9 | 40.3 | +2.2 | -0.3 | 35.2 | 43.9 |

The year 2007, like the previous one, was also one of favourable thermal conditions for chicory cultivation. Since the beginning of plants' vegetation, throughout the following months of the cultivation and until September, the mean temperatures of each month were higher than the mean temperatures of many years, in May by 2.0°C, in June by 1.6°C, in July by 1.3°C, in August by 1.1°C, and in September by 0.1°C. The mean temperature in October was lower by 0.3°C than the mean value of many years.

Considering the precipitation, the year 2006 was a very unfavourable period for the emergencies and growth of chicory. In May, the monthly sum of precipitation was higher than the many-years' sum only by 2.0% (tab. 1). The two successive months, June and July, were a period of sporadic rainfalls, whose monthly sums considerably differed from the mean values of many years. In June, the studies found out by 42.4% less, and in July by 91.3% less rainfalls as compared to the many-years' mean values. In August, the monthly sum of precipitation was higher than the many-years' sum by 184.5%. The following two months, September and October, were dry ones. In September and October, the mean sums of rainfalls were lower than the sums of many years, by 78.9% and 64.8%, respectively.

The beginning of the vegetation period in 2007 was favourable considering the rainfalls. The monthly sums of rainfalls in May, June and July were higher than the mean values of many years. In May, they were higher by 39.8%, in June by 33.4% and in July

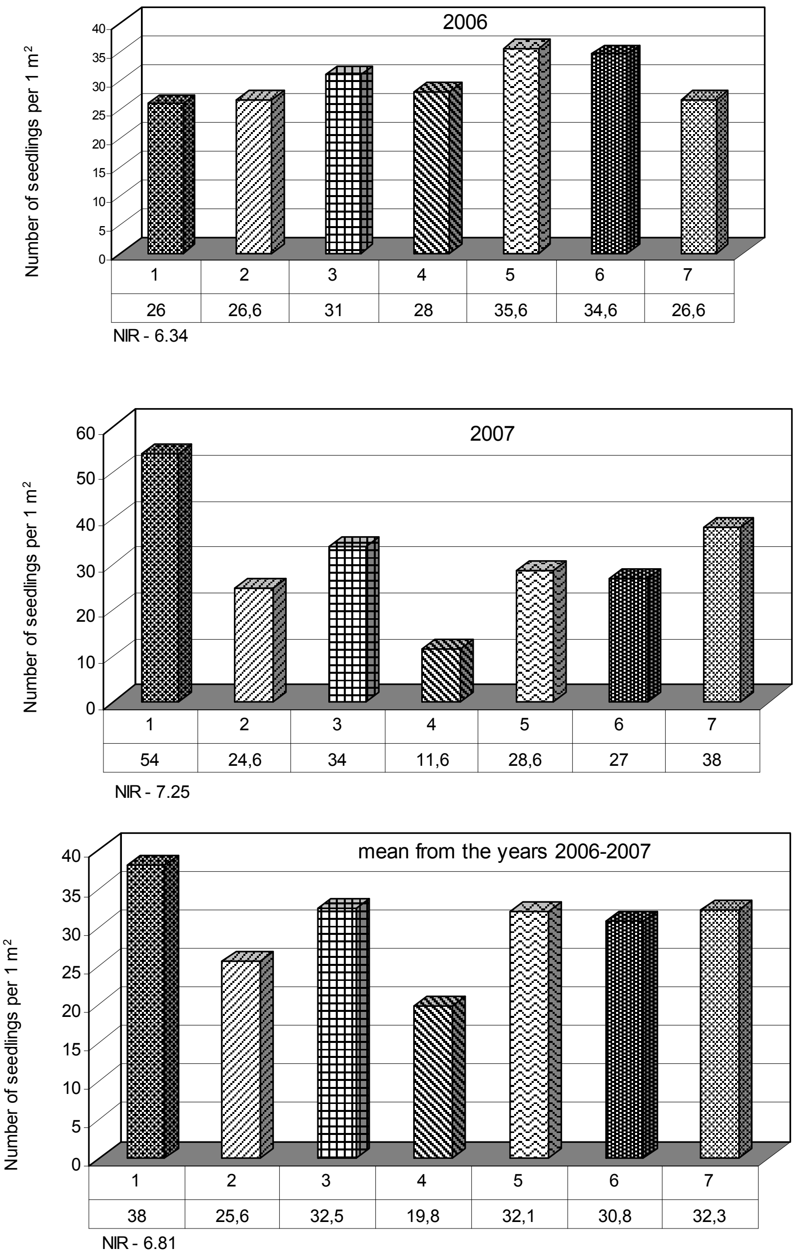



Fig. 1. Field stand of chicory seedlings: 1 – oats mulch + spring ploughing, 2 – oats mulch + pre-winter ploughing, 3 – tansy phacelia mulch + spring ploughing, 4 – tansy phacelia mulch + pre-winter ploughing, 5 – spring vetch mulch + spring ploughing, 6 – spring vetch mulch + pre-winter ploughing, 7 – conventional cultivation, uprawa tradycyjna

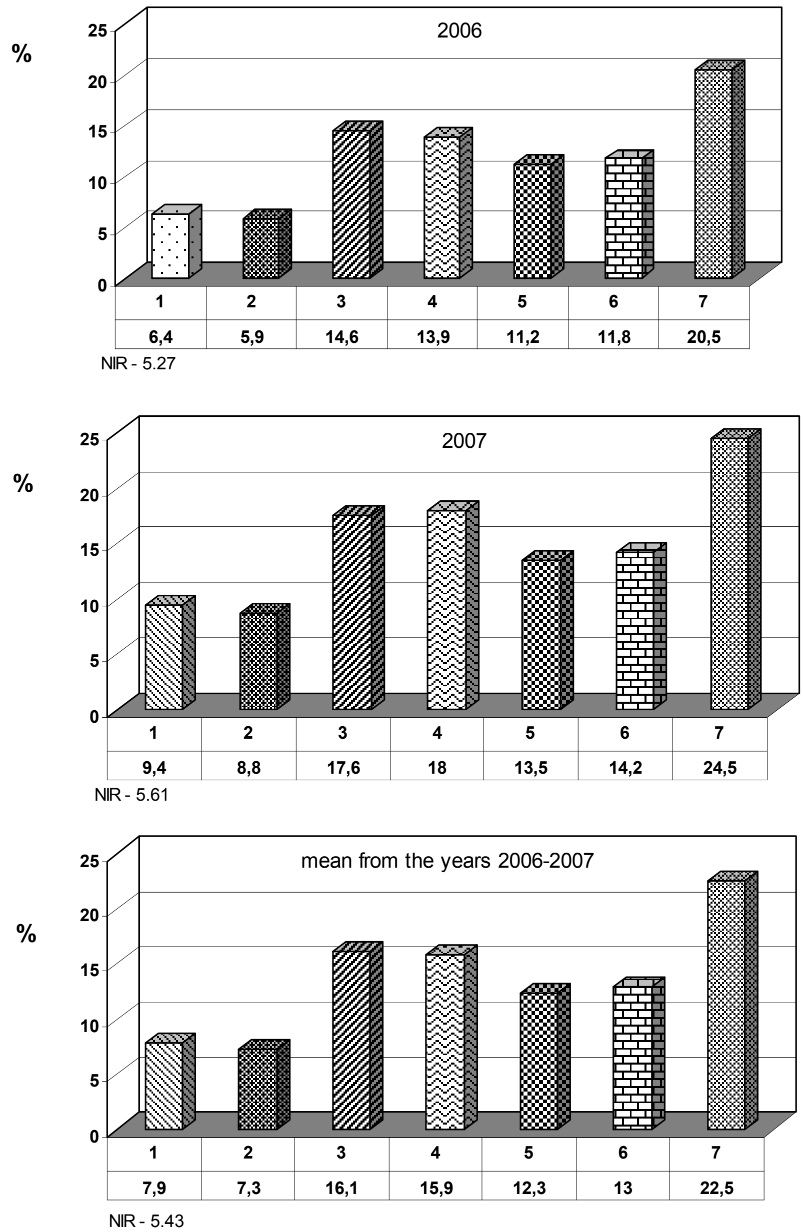



Fig. 2. Participation of diseased chicory seedlings: 1 – oats mulch + spring ploughing, 2 – oats mulch + pre-winter ploughing, 3 – tansy phacelia mulch + spring ploughing, 4 – tansy phacelia mulch + pre-winter ploughing, 5 – spring vetch mulch + spring ploughing, 6 – spring vetch mulch + pre-winter ploughing, 7 – conventional cultivation

by 15.4%. In August, definitely less rainfalls were observed. The monthly sum in that month was lower than the many-years' sum by 46.1%. The situation improved only in September. The sum of rainfalls was higher than the sum of many years by 149.1%. In October, less rainfalls were observed and their sum was lower than the mean sum of many years by 56.1% (tab. 1).

Good emergencies of plants were observed in the objects with the cultivation of oats, which was managed in spring when the medium ploughing was performed. This cultivation created good conditions for the growth of chicory. The number of plants in that combination was, on average, 38.0 per $m^{-2}$ (fig. 1). The smallest density of plants (19.8 per $m^{-2}$) was found in objects where the tancy phacelia biomass was covered with the soil in the pre-winter period. Mulching the soil with oats, spring vetch and tancy phacelia, with the application of spring plough, showed a tendency to a favourable effect on the density of chicory plants per one unit of area.

Studies conducted by Patkowska and Konopiński [2008b] showed that pre-emergence blight and seedling necrosis of chicory growing in a growth chamber were caused by different soil-borne fungi. They could also decrease the plant density on the plantation.

The proportion of the infected seedlings of *Cichorium intybus* var. *sativum* varied depending on the species of the mulching plant. It ranged from 7.3% to 22.5% (fig. 2). In each year of studies the smallest number of infected seedlings was observed after the mulch of oats, while slightly more after mulching the soil with spring vetch or tansy phacelia. The highest proportion of infected seedlings of root chicory was found out in the conventional cultivation (20.5% and 24.5%, depending on the year of studies) (fig. 2). The cultivation system, i.e. the spring or pre-winter plough had no significant effect on the proportion of infected seedlings of chicory. As reported by Plentinger et al. [2000], the emergences and the yield of leaf chicory in the climatic conditions of Holland were considerably lowered as a result of infection by *Pythium* sp., *Phytophthora* sp. and *Sclerotinia sclerotiorum.*

Hermann [2006] and Trdan et al. [2005] report that the aboveground parts of different cultivars of leaf chicory in Belgium and Slovenia are threatened by *Erysiphe cichoracearum* DC. and *Puccinia cichorii* (DC.) Bell. There is no information on the fungi threatening the cultivation of root chicory in our country.

**Laboratory mycological analysis.** The present studies found out that yellowing seedlings with inhibited growth and development occurred on the plots of particular experimental combinations. After digging them out, it turned out that brown necrotic spots were found on their roots (phot. 1). Necrosis and the powder from the mycelium hyphas were also observed on the roots after the harvest of chicory (phot. 2). Symptoms of rot were visible on the cross-section of the infected roots (phot. 3).

The mycological analysis of the infected seedlings of chicory showed varied quantitative and qualitative composition of the fungi colonizing the underground parts. Totally, 510 fungi isolates belonging to 11 genera were obtained from chicory seedlings (tab. 2). The greatest number of fungi (122 isolates) was obtained from the seedlings of root chicory cultivated conventionally, i.e. without cover crops. Slightly more fungi were isolated from the seedlings of the studied plant cultivated after tansy phacelia or spring vetch as cover crops. The smallest number of fungi (45 isolates) was isolated

Table 2. Fungi isolated from diseased seedlings of chicory (sum from the years 2006–2007)

| Fungus species | Experimental combination – Number of isolates | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | 6 | 7 | total |
| *Alternaria alternata* (Fr.) Keissler | 2 | 4 | 10 | 9 | 6 | 4 | 15 | 50 |
| *Alternaria cichorii* Nattrass | 4 | 3 | 14 | 10 | 5 | 7 | 17 | 60 |
| *Alternaria tenuissima* (Kunze) Wiltshire | – | – | 3 | 1 | 1 | 2 | 5 | 12 |
| *Cladosporium cladosporioides* (Fres.) G. A. de Vries | 2 | 1 | 2 | – | 1 | 3 | 2 | 11 |
| *Dischloridium roseum* (Petch) Seifert & W. Gams | 1 | 2 | 3 | – | – | – | – | 6 |
| *Fusarium culmorum* (W.G.Sm.) Sacc. | 3 | 4 | 8 | 7 | 5 | 4 | 12 | 43 |
| *Fusarium oxysporum* Schltdl. | 8 | 10 | 12 | 15 | 9 | 10 | 19 | 83 |
| *Humicola grisea* Traaen | – | – | 1 | 3 | 1 | – | 1 | 6 |
| *Mucor hiemalis* Wehmer | 1 | 2 | 2 | 1 | 1 | – | 5 | 12 |
| *Penicillium janczewskii* Zaleski | – | – | 4 | 2 | 2 | 3 | 3 | 14 |
| *Penicillium verrucosum* Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok | 2 | 3 | 5 | 6 | 4 | 2 | 6 | 28 |
| *Pythium irregulare* Buisman | 4 | 2 | 6 | 6 | 3 | 4 | 11 | 36 |
| *Rhizoctonia solani* Kühn | 5 | 4 | 12 | 15 | 11 | 10 | 18 | 75 |
| *Sclerotinia sclerotiorum* (Lib.) de Bary | – | – | 3 | 3 | – | 2 | 5 | 13 |
| *Trichoderma koningii* Oud. | 5 | 7 | 2 | 2 | 6 | 3 | 1 | 26 |
| *Trichoderma viride* Pers. | 8 | 6 | 4 | 4 | 6 | 5 | 2 | 35 |
| Total | 45 | 48 | 91 | 84 | 61 | 59 | 122 | 510 |

*1 – oats mulch + spring ploughing; 2 – oats mulch + pre-winter ploughing; 3 – tansy phacelia mulch + spring ploughing; 4 – tansy phacelia mulch + pre-winter ploughing  5 – spring vetch mulch + spring ploughing; 6 – spring vetch mulch + pre-winter ploughing; 7 – conventional cultivation

Table 3. Fungi isolated from diseased roots of chicory after harvest (sum from the years 2006–2007)

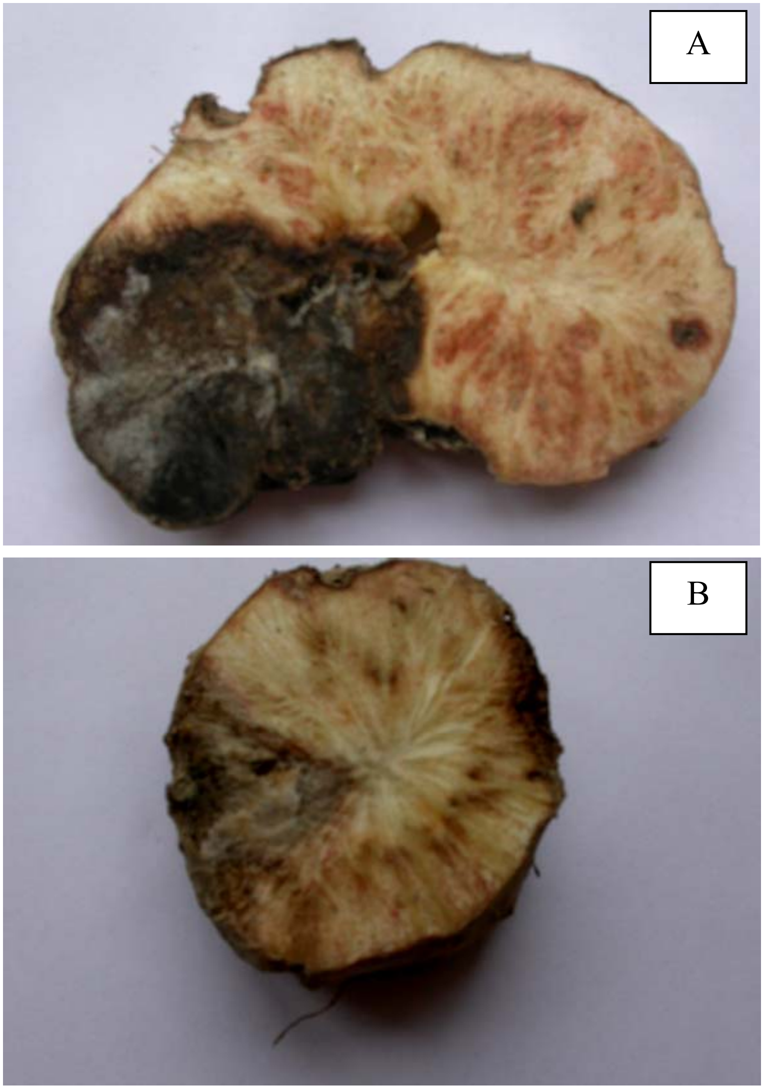
| Fungus species | Experimental combination / Number of isolates | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | 6 | 7 | total |
| *Acremonium strictum* W. Gams | 2 | 1 | – | 1 | 2 | 2 | 2 | 10 |
| *Alternaria alternata* (Fr.) Keissler | 3 | 4 | 11 | 8 | 5 | 7 | 12 | 50 |
| *Alternaria cichorii* Nattrass | 6 | 5 | 12 | 12 | 7 | 6 | 16 | 64 |
| *Alternaria tenuissima* (Kunze) Wiltshire | 2 | 1 | 4 | 1 | 2 | 3 | 6 | 19 |
| *Aspergillus flavus* Link | 3 | 1 | 5 | 2 | 3 | 2 | 4 | 20 |
| *Botrytis cinerea* Pers. | – | – | 3 | 2 | – | – | 3 | 8 |
| *Cladosporium cladosporioides* (Fres.) G.A. de Vries | 2 | 1 | – | 2 | 3 | 2 | 1 | 11 |
| *Fusarium culmorum* (Wm. G. Sm.) Sacc. | 5 | 3 | 6 | 4 | 5 | 5 | 10 | 38 |
| *Fusarium oxysporum* Schltdl. | 11 | 10 | 14 | 11 | 12 | 10 | 16 | 84 |
| *Fusarium solani* (Mart.) Sacc. | 2 | 1 | 5 | 3 | 3 | 2 | 9 | 25 |
| *Mucor mucedo* Fresen. | 3 | 2 | 5 | 1 | 3 | 1 | 4 | 19 |
| *Penicillium meleagrinum* Biourge | 3 | – | 3 | 2 | 2 | 1 | 3 | 14 |
| *Penicillium verrucosum* Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok | 3 | 2 | 5 | 6 | 3 | 3 | 5 | 27 |
| *Penicillium verrucosum* Dierckx var. *verrucosum* Samson, Stolk et Hadlok | 4 | 3 | 6 | 4 | 5 | 3 | 8 | 33 |
| *Phoma cichoracearum* Sacc. | – | – | 4 | 2 | 3 | 2 | 7 | 18 |
| *Phytophthora* sp. | 4 | 2 | 7 | 7 | 6 | 5 | 10 | 41 |
| *Ramularia cichorii* Dearn.et House | – | 1 | – | – | 2 | 3 | 4 | 10 |
| *Rhizoctonia solani* Kühn | 6 | 5 | 8 | 5 | 7 | 7 | 11 | 49 |
| *Sclerotinia sclerotiorum* (Lib.) de Bary | 9 | 10 | 12 | 9 | 11 | 8 | 15 | 74 |
| *Sclerotium rolfsii* Sacc. | – | – | 3 | 5 | 2 | 2 | 5 | 17 |
| *Thielaviopsis basicola* (Berk. et Broome) Ferr. | 2 | 1 | 1 | 1 | 2 | – | 4 | 11 |
| *Verticillium dahliae* Kleb. | 3 | 2 | 7 | 9 | 5 | 4 | 12 | 42 |
| *Trichoderma koningii* Oud. | 6 | 5 | 2 | 2 | 3 | 2 | 2 | 22 |
| Total | 79 | 60 | 123 | 99 | 96 | 80 | 169 | 706 |

*1 – oats mulch + spring ploughing; 2 – oats mulch + pre-winter ploughing; 3 – tansy phacelia mulch + spring ploughing; 4 – tansy phacelia mulch + pre-winter ploughing; 5 – spring vetch mulch + spring ploughing; 6 – spring vetch mulch + pre-winter ploughing; 7 – conventional cultivation

Phot. 1. Necrosis on chicory seedlings roots (photo by E. Patkowska)

Phot. 2. Chicory root with *Sclerotium rolfsii* mycelium (photo by E. Patkowska)

from the infected seedlings of chicory cultivated after mulch of oats ploughed over in spring. The cultivation system, i.e. spring or pre-winter plough, had no significant effect on the population of fungi isolated from the examined seedlings (tab. 2). Regardless of the species of the mulching plant, fungi considered as potential pathogens were frequently obtained from the diseased seedlings of root chicory. Those included *Alternaria alternata* (Fr.) Keissler, *Alternaria cichorii* Nattrass, *Fusarium* sp., *Pythium irregulare* Buisman, *Rhizoctonia solani* Kühn and *Sclerotinia sclerotiorum* (Lib.) de Bary. The proportion of those fungi was, respectively, 9.8%, 11.8%, 24.7%, 7.0%, 14.7% and 2.5% (fig. 3). Considerable pathogenicity of the enumerated general of fungi towards scorzonera seedlings was shown in the studies by Patkowska and Konopiński [2008a].




Phot. 3. The rot on the cross-section of chicory roots caused by: A – *Alternaria cichorii*, B – *Rhizoctonia solani* (photo by E. Patkowska)

In the present studies, *Fusarium* spp. were represented by such species as *Fusarium culmorum* (Wm.G.Sm.) Sacc. (8.4%, totally) and *F. oxysporum* Schltdl. (16.3%). The enumerated plant pathogens caused the seed necrosis, root rot and the necrosis of the aboveground parts of chicory. Similar disease symptoms resulting from the infection of leaf chicory plants by *Alternaria cichorii* and *Pythium mastophorum* were observed by Lima et al. [2003] and Plentinger et al. [2000]. Fungi considered saprobiotic such as

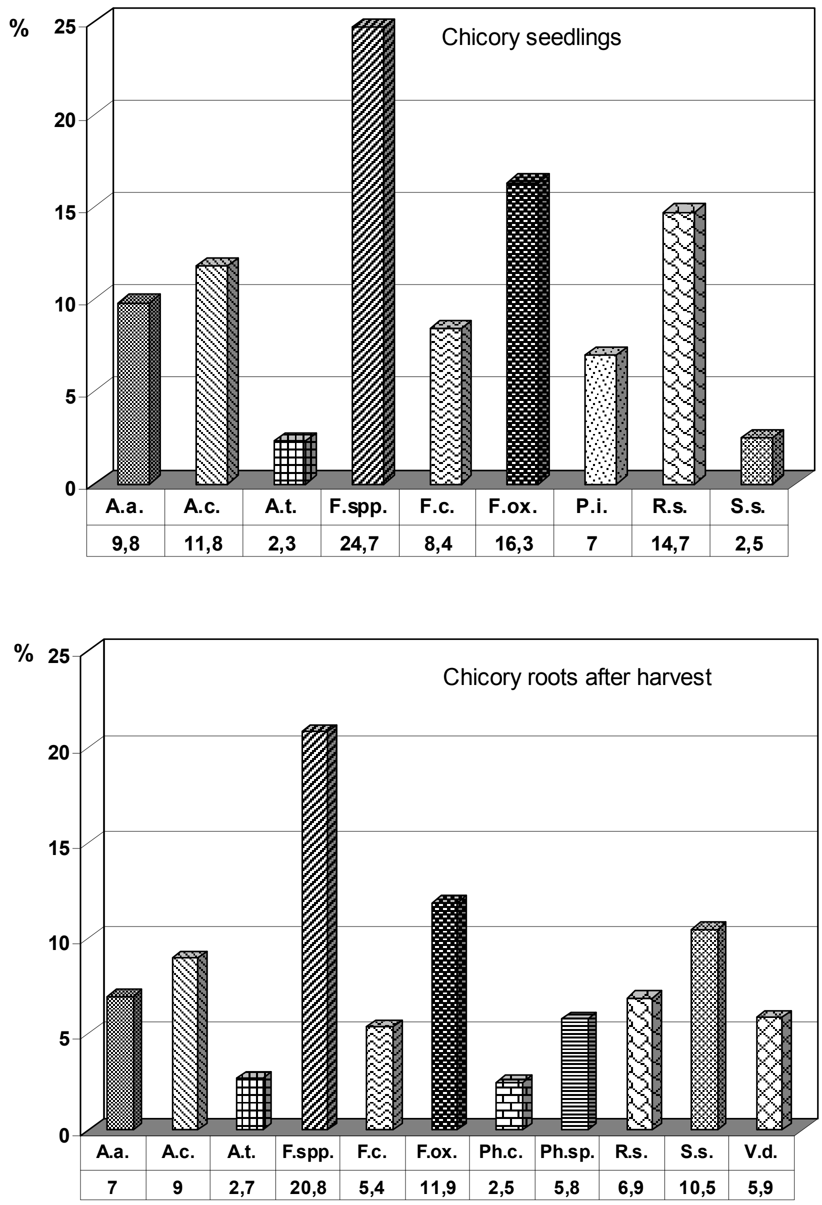



Fig. 3. Total participation of selected fungi isolated from chicory plants (mean from the years 2006–2007): A.a. – *Alternaria alternata*, A.c. – *Alternaria cichorii,* A.t. – *Alternaria tenuissima*, F.spp. – *Fusarium* spp., F.c. – *Fusarium culmorum*, F.ox. – *Fusarium oxysporum*, Ph.c. – *Phoma cichoracearum*, Ph.sp. – *Phytophthora* sp., P.i. – *Pythium irregulare*, R.s. – *Rhizoctonia solani*, S.s. – *Sclerotinia sclerotiorum*, V.d. – *Verticilium dahliae*

*Dischloridium roseum* (Petch) Seifert & W. Gam., *Cladosporium cladosporoides* (Fres) G.A. de Vries, *Humicola grisea* Traaen, *Mucor hiemalis* Wehmer, *Penicillium janczewskii* Zaleski, *Penicillium verrucosum* Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok, *Trichoderma koningii* Oud. and *T. viride* Pers. were also isolated from the seedlings of root chicory (tab. 2).

After the harvest, chicory roots with disease symptoms were submitted to a mycological analysis. Totally, 706 fungi isolates belonging to 17 genera were obtained from chicory roots (tab. 3). The smallest number of fungi was isolated from the roots of chicory cultivated after the mulch of oats, slightly more after mulching the soil with spring vetch or tansy phacelia and the most in case of the conventional cultivation (169 isolates) (tab. 3). Spring or pre-winter ploughing also had no effect on the population of fungi isolated from the roots of chicory after the harvest. The following fungi considered to be pathogenic were isolated: *Alternaria alternata, A. cichorii, A. tenuissima* (Kunze) Wiltshire, *Botrytis cinerea* Pers., *Fusarium culmorum, F. oxysporum, F. solani* (Mart.) Sacc., *Phoma cichoracearum* Sacc., *Phytophthora* sp., *Ramularia cichorii* Dearn.et House, *Rhizoctonia solani, Sclerotinia sclerotiorum, Sclerotium rolfsii* Sacc., *Thielaviopsis basicola* (Berk. et Broome) Ferr. and *Verticilium dahliae* Kleb. Among the enumerated fungi, the greatest total proportion was observed for *A. cichorii* (9.0%), *F. oxysporum* (11.9%) and *S. sclerotiorum* (10.5%). *A. alternata* (7.0%), *Phytophthora* sp. (5.8%), *R. solani* (6.9%) and *V. dahliae* (5.9%) were also characterized by big proportions (fig. 3). Within saprobiontic species, *Acremonium* spp., *Aspergillus* spp., *Cladosporium* spp. *Mucor* spp., *Penicillium* spp. and *Trichoderma* spp. were isolated (tab. 3). As reported by Geldenhuis et al. [2006], black rot of the roots of chicory cultivated in South Africa was caused, for example, by pathogen *Thielaviopsis basicola.* According to Jonghe et al. [2005], fungus *Phytophthora cryptogea* caused the root rot of leaf chicory. Besides, different species of *Altenaria* spp. (especially *A. cihorii* and *A. sonchi*) posed a threat to the plants of leaf chicory cultivated in Brazil [Lima et al. 2003]. In addition, studies by Golden [1984] also pointed to considerable harmfulness of *Sclerotinia sclerotiorum, Sclerotium rolfsii, Ramularia cichorii* and *Verticillium dahliae* towards chicory plants. Pathogenicity testes carried out in a grown chamber showed that pre-emergence damping-off of chicory seeds, and thus no germination, was caused by *Sclerotinia sclerotiorum, Pythium irregulare* and *Alternaria alternata* [Patkowska and Konopiński 2008b].

The present studies confirmed the positive effect of cover crops on the growth and healthiness of *Cichorium intybus* var. *sativum.* It should be supposed that the mulch of oats and spring vetch inhibited the development of soil-borne fungi and – consequently – improved the healthiness of the examined plant. According to Abdul-Baki et al. [2002], Jamiołkowska [2007] and Patkowska and Konopiński [2008a, 2008c, 2011], cover crops decrease weed infestation, lower the costs of production and reduce the activity of pathogens in the soil. Besides, as reported by Lüning et al. [1978], oats roots contain avenacine, which has strong anti-fungal properties.

## CONCLUSIONS

1. The emergences and the proportion of infected chicory seedlings depended on the species of the mulching plant.
2. The smallest number of infected seedlings was obtained after the mulch with oats as cover crops.
3. *Alternaria alternata, A. cichorii, A. tenuissima, Fusarium oxysporum, Phoma cichoracearum, Sclerotinia sclerotiorum* and *Sclerotium rolfsii* proved to be the most harmful towards the studied underground parts of chicory.
4. The system of cultivation had no significant effect on the total population of fungi.

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## SZKODLIWOŚĆ GRZYBÓW ODGLEBOWYCH DLA CYKORII KORZENIOWEJ (*Cichorium intybus* L. var. *sativum* Bisch.) UPRAWIANEJ Z ZASTOSOWANIEM ROŚLIN OKRYWOWYCH

**Streszczenie.** Cykoria jest rośliną zielną, należącą do rodziny Asteracae. Roślina ta jest bogatym źródłem polisacharydów, witamin, kwasów i soli mineralnych. Badania dotyczyły szkodliwości grzybów odglebowych dla cykorii korzeniowej, wysokoinulinowej rośliny o dużych walorach prozdrowotnych, uprawianej z zastosowaniem takich roślin okrywowych jak owies, facelia i wyka siewna. Spośród roślin mulczujących, owies wpłynął najkorzystniej na liczebność i zdrowotność siewek oraz korzeni cykorii. Najbardziej szkodliwymi dla siewek okazały się *Alternaria alternata, A. cichorii, Fusarium oxysporum, Pythium irregulare, Rhizoctonia solani* i *Sclerotinia sclerotiorum*. Korzenie starszych roślin cykorii porażane były ponadto przez *A. tenuissima, Botrytis cinerea, F. culmorum, F. solani, Phoma cichoracearum, Phytophthora* sp., *Ramularia cichorii, Sclerotium rolfsii, Thielaviopsis basicola, Verticilium dahliae.*

**Słowa kluczowe:** owies, facelia błękitna, wyka siewna, mulcz, fitopatogeny cykorii

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