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Mycobionta of birch and birch stump roots and its possible effect on the infection by *Armillaria* spp. II.

HANNA KWAŚNA

Department of Forest Pathology, University of Agriculture, ul. Wojska Polskiego 71 c,
60-625 Poznań, Poland

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This paper presents the differences in size and structure of mycobionta communities occurring in soil and on/in roots of a 30-year-old birch and its stumps 2 years after cutting of the trees. Special attention was paid to the occurrence of *Zygorhynchus moelleri* and *Trichoderma viride*. The first species due to the metabolites produced may presumably stimulate the infection by *Armillaria*. The second species is a well-known antagonist of *Armillaria*. *Z. moelleri* accounted only for 2.6, 1.3 and 9.1 % of the total number of isolates in rhizoplane as well as in the fine and thick roots of stumps, respectively. *Trichoderma viride* and *T. virens* were present in roots of live birch and its stumps only occasionally. The relatively big population of *Mycelium radicis atrovirens* – particularly in the fine roots of stumps is attributed to their high vitality and relatively lower level of root decomposition. It seems that the rate of stump root decomposition does not favour their colonization by *Z. moelleri* and its supposed contribution in enhancing the infection by *Armillaria* might not be so distinct as on stumps of 49-year-old birches.

Key words: *Armillaria* spp., birch, mycobionta, roots, stumps.

Kwaśna (1996 a) suggests that the high frequency of *Zygorhynchus moelleri* associated with the absence of *Trichoderma viride* on/in 2-year-old stumps of 49-year-old birch (*Betula verrucosa*) may favour the infection of stumps by *Armillaria*. *Z. moelleri* is known to produce indole-3-ethanol and indole-3-acetic acid stimulating the growth and development of *Armillaria* rhizomorphs. *T. viride* is a well--known antagonist of *Armillaria*.

In order to determine whether similar relationships are found between birch and fungi on/in roots of 2-year-old stumps of younger trees, the structure of mycobionta in soil and on/in stump roots of 30-year old birches was investigated.

MATERIAL AND METHODS

In September 1991 roots were collected from 30-year-old birches in Huta Pusta Forest District (western Poland, 17° 10' E, 52° 50' N), division 37 d. The birch

comprised 10 % of the Scots pine stand. Trees were cut down and after 2 years roots were collected from their stumps. Root samples were taken from each of the 5 trees and 5 stumps. The soil samples were taken from beneath the roots of each tree and stump. Isolation of the soil, rhizoplane, rhizosphere and root fungi was carried out according to M a ń k a (1974). For more details see part I (K w a ś n a, 1996 a).

RESULTS

Table 1 presents a list of all fungi isolated from the soil, rhizoplane, rhizosphere, fine and thick roots of the 30-year-old birch and 2 year-old birch stumps. Altogether 116 fungal species were found. Table 2 presents the frequency of occurrence of the most common taxa in soil/root habitat of tree and stump roots. The total number of fungi isolated from the soil surrounding the roots of live trees and stump roots was 888 and 282, respectively. These fungi communities were represented by 20 and 39 species, respectively. The frequency of *Mucorales* decreased from 45.0 % of the total number of isolates in soil beneath the roots of the live trees to 25.7 % in soil around the stump roots. The density of *Penicillia* and *Trichoderma* was stable. In both soils the most common species were: *M. vinacea*, *P. daleae*, *P. adametzii*, and *P. janczewskii*. Except for *P. daleae* the frequency of the remaining fungi decreased in the soil beneath stump roots. *G. murorum* var. *felina*, *G. reessii*, *M. angusta*, *P. decumbens*, *P. simplicissimum*, *S. pithyophila*, *S. schenckii* and *T. asperum* were detected exclusively in the soil beneath the stump roots. In soil surrounding the roots of living trees and stumps *Penicillia* population was represented by 6 and 11 species, respectively.

The rhizoplane and rhizosphere of live birch roots were inhabited by 584 and 194 isolates represented by 27 and 25 species. In the rhizoplane of the stump roots the density of fungi was much higher. The total number of isolates amounted to 2421. This large community was represented by 36 species. In the rhizosphere of the fine roots of stumps there were only 40 isolates represented by 14 species. On stump roots *Mucorales* density increased to 48.0 and 20.0 % of the total number of isolates in rhizoplane and rhizosphere, respectively. The above taxon was represented mostly by *M. vinacea*. *Z. moelleri* was absent on the roots of the live trees. In the rhizoplane of the stump roots it comprised 2.6 % of the total number of isolates. Compared to the live roots, the frequency of *Penicillia* decreased on stump roots to 46.4 and 32.5 % of the total number of isolates in rhizoplane and rhizosphere, respectively. The taxon was represented by a similar number of species in rhizoplane and rhizosphere. Compared to the roots of living trees, the number of isolates from fine roots of stumps increased over 65 % and was 392. The number of species representing the community increased from 22 to 34. The frequency of *Mucorales* decreased from 56.1 to 26.5 % and that of *Penicillia* increased from 4.6 to 27.4 % of the total number of isolates. Among *Mucorales* the most common species was *M. vinacea* which occurred in smaller density in the fine roots of stumps than in the fine roots of the living

trees. *Z. moelleri* in the fine roots of stumps accounted only for 1.3 % of all the isolates. Among *Penicillia* the most common species was *P. daleae* whose frequency increased markedly, compared to roots of the live trees. The thick roots of the live trees and stumps were inhabited by a similar number of isolates but the number of species representing the communities was 28 on stumps and only 10 on the living trees. *Mycelium radicis atrovirens* which was the dominating species in thick roots of the live trees occurred with a frequency of 34.6 % in thick roots of stumps. The density of *Mucorales* and *Penicillia* increased in stump thick roots. *Cylindrocarpon destructans* was detected mostly in fine roots of live trees and occurred more frequently in the thick roots of stumps. *Oidiodendron* species were found mostly on the surface of roots from the live trees. Only single isolates of *Trichoderma* spp. occurred in the soil and on/in the roots. They were more frequently found in roots. Fungi occurring in specific habitats are listed in Table 3.

DISCUSSION

This paper presents the changes in the size and structure of fungal communities in soil and on/in roots of birch stumps in the 30-year-old Scots pine stand, two years after trees were cut down. The rate of afforestation of stand was 1.0 and was higher than in the 49-year-old stand where the birch soil/root mycobionta was studied before (K w a ś n a, 1996 a). In a younger stand, due to the higher rate of afforestation, the accumulation of organic matter in the litter, moisture of the soil and accumulation of $C0_2$ in the ground covered by a thicker layer of litter were higher. Dense canopy reduces the amount of solar radiation reaching the ground which prevents the increase of its temperature. The aeratin of the more dense stand is also lower. These environmental factors might influence the species composition of the fungal communities on/in stump roots. The physical, chemical and biological factors may have modified not only the frequency of fungi but also their physiological properties, including degradative ability (B ä ä t h, S ö d e r s t r ö m, 1980).

Many soil microfungi have a wide ecological amplitude and were found in both stands (K w a ś n a, 1996 a) but others showed very strict ecological specificity. The decrease in density of fungi in soil beneath the birch stumps was observed in the 30- and 49-year-old stands (K w a ś n a, 1996 a). The fungi communities were threefold smaller, compared to those beneath the living trees. In the 30-year-old stand the decrease in the density was not correlated with the decrease in the number of species. The soil beneath the stumps comprised twice as many fungal species as the soil beneath the live trees. The soil/root microfungal community except the microclimate, microfungal and microfaunal associates is created mostly by the chemical properties of the substrate. The decrease in the size of soil fungi community and the increase in its diversity might be mostly due to absence of the roots exudates and the small accumulation of organic matter at relatively low and different rate of decomposition.

Table 1

The frequency (%) of fungi in soil-root habitat of the 30-year-old birch and its stumps

Species	Live trees					Stumps				
	soil	rhizopl.	rhizosp.	fine roots	thick roots	soil	rhizopl.	rhizosp.	fine roots	thick roots
Absidia coerulea Bainier	0	0	0	0	0	0	0	0	+	0
A. cylindrospora Hagem	4.8	2.9	0	8.4	0	1.0	2.1	0	0	0
A. glauca Hagem	0	0	1.6	0	0	0	0	0	0	0
Acremonium apii (M. A. Sm. et Ramsey) W. Gams	0	1.0	0	0	0	0	0	0	0	0
A. fusidioides (Nicot) W. Gams	1.0	0	+	0	0	0	0	0	0	0
Arthrinum phaeospermum (Corda) M. B. Ellis	0	0	0	0	0	+	0	0	0	0
Ascomycotina	0	0	0	0	0	0	0	0	+	0
Aspergillus kanagawaensis Nehira	+	0	0	0	0	1.1	0	0	1.0	0
A. niveus Blochwitz	0	3.8	0	0	0	1.8	+	2.5	0	0
A. repens (de Bary) Fischer	+	0	1.0	0	0	1.1	0	0	0	0
A. ruber Thom et Church.	0	0	0	0	+	0	0	0	0	0
Auxarthron umbrinum (Boud.) Orr et Plunkett	0	0	0	0	0	+	0	0	0	0
Basidiomycotina Kcb 28	0	0	0	+	0	0	0	0	9.4	1.8
Basidiomycotina Kcb 29	0	0	0	0	0	0	0	0	+	0
Beauveria bassiana (Balsamo) Vuill.	0	+	0	0	0	0	0	0	0	0
Botrytis cinerea Pers.	0	0	0	1.0	0	0	+	0	+	6.4
Chrysosporium merdarium (L. ex G.) Carm.	2.8	0	+	0	0	2.5	2.3	2.5	+	0
Ch. pannorum (Link) Hughes	0	+	0	+	0	0	+	0	0	0
Cladosporium herbarum Link ex Fr.	0	0	2.1	0	0	0	+	0	+	+
C. sphaerospermum Penz.	+	0	0	0	0	0	0	0	0	0
Cladosporium state of *Amorphoteca resinae* Parb.	0	0	0	0	0	0	+	0	0	0
Cylindrocarpon destructans (Zinssm.) Scholten	0	0	0	7.6	1.7	0	+	0	3.1	6.4
C. didymum (Hartig) Wollenw.	0	0	0	0	+	0	0	0	0	0
Epicoccum nigrum Link	0	+	0	0	+	0	0	0	+	0
Exophiala sp.	0	+	0	0	0	0	1.0	27.5	0	6.4
E. jeanselmei (Lang.) McGinnis et Padhye	0	+	0	0	0	0	0	0	0	0

Fusarium avenaceum (Corda) Sacc.	0	0	0	0	0	0	0	0	0	1.4
Gliomastix murorum var. *felina* (Marchal) S. Hughes	0	0	0	0	0	1.1	0	5.0	0	0
Gymnoascus reessii Baranetzky	0	0	0	0	0	2.1	0	0	0	0
Hormiscium sp.	0	0	0	0	2.2	0	0	0	0	0
Humicola grisea (Riv.) Galloway	+	0	1.0	+	0	1.0	0	0	0	0
Memnoniella echinata (Riv.) Galloway	0	0	0	+	0	0	0	0	0	0
Mortierella alpina Peyr.	0	0	1.0	0	0	0	0	0	0	0
M. angusta Linn.	0	0	0	0	0	1.0	0	0	0	0
M. gracilis Linn.	0	1.0	0	3.4	0	+	+	0	1.0	0
M. humilis Linn.	0	2.4	0	0	0	0	+	0	1.0	0
M. hygrophila Linn.	0	0	0	0	0	0	2.4	0	0	0
M. hygrophila var. *minuta* Linn.	0	0	0	0	+	0	0	0	+	0
M. isabellina Oudemans et Koning	0	0	0	0	0	+	5.5	0	1.8	+
M. microspora Wolf var. *macrocystis* (Gams) Linn. W. Gams	0	0	0	0	0	0	0	0	0	+
M. minutissima van Tieghem	0	3.1	0	0	0	0	+	0	0	0
M. nana Linn.	+	0	0	0	0	1.4	+	0	+	0
M. ramanniana (Moller) Linn.	+	0	0	0	0	0	0	0	+	0
M. spinosa Linn.	0	0	0	1.7	0	0	+	0	+	0
M. vinacea Dixon-Stewart	38.6	19.7	10.8	33.8	2.6	21.6	33.0	20.0	19.4	8.6
M. zonata Linn.	0	0	0	8.4	0	0	0	0	0	0
Mucor sp.	1.1	0	0	0	0	0	0	0	0	0
M. laxorhizus Ling-Young var. *ovalispora*	0	0	0	0	0	0	0	0	0	+
M. miehei Cooney et Emerson	0	0	0	0	0	0	1.0	0	0	0
Mycelium radicis atrovirens Melin	0	0	2.6	7.6	90.5	0	0	0	18.4	34.6
Oidiodendron echinulatum Barron	0	0	0	0	0	+	0	0	0	0
O. griseum Robak	0	+	0	0	0	0	+	0	+	0
O. tenuissimum (Peck) Hughes	0	8.9	26.8	0	0	+	0	0	0	0
Penicillium adametzii Zaleski	21.8	8.9	2.6	0	1.3	7.5	1.9	0	1.6	0
P. aurantiogriseum Dierckx	0	0	0	+	0	0	0	0	0	0
P. chrysogenum Thom	+	1.0	0	0	0	0	0	0	0	0
P. citrioviride Biourge	1.1	0	0	0	0	0	0	0	0	0
P. citrinum Thom	+	0	1.0	0	0	+	+	2.5	0	0

cont. Tab. 1

Species	Live trees					Stumps				
	soil	rhizopl.	rhizosp.	fine roots	thick roots	soil	rhizopl.	rhizosp.	fine roots	thick roots
P. commune Thom	0	+	0	0	0	0	0	0	0	+
P. corymbiferum Westling	0	0	0	0	0	0	0	2.5	0	0
P. crustosum Thom	0	10.3	0	0	0	0	0	0	0	0
P. daleae Zaleski	17.7	8.7	6.2	3.8	0	28.4	32.0	17.5	20.2	3.6
P. decumbens Thom	0	0	0	0	0	1.0	0	0	0	0
P. janczewskii Zaleski	7.0	1.4	0	0	0	4.6	3.3	2.5	1.3	2.3
P. lanosum Westling	0	0	0	0	0	0	0	2.5	0	0
P. paxilli Bainier	0	1.0	0	0	0	0	0	0	0	0
P. purpurescens (Sopp.) Biourge	0	0	+	0	0	0	0	0	0	0
P. purpurogeum Stoll	0	0	27.3	0	0	1.4	0	0	0	0
P. raistrickii G. Sm.	0	0	0	0	0	0	+	0	+	0
P. simplicissimum (Oudem.) Thom	0	0	0	0	0	1.4	0	0	0	0
P. solitum Westling	0	0	0	+	0	0	+	0	0	0
P. spinulosum Thom	0	0	0	0	0	1.0	+	0	0	1.8
P. steckii Zaleski	0	0	0	0	0	3.6	8.5	5.0	3.8	1.0
P. stoloniferum Thom	0	0	0	0	0	+	0	0	0	0
P. variabile Sopp.	0	19.0	0	0	0	1.8	0	0	0	0
P. waksmanii Zaleski	0	0	1.6	0	0	0	0	0	0	+
Phialophora cyclaminis v. Beyma	0	0	0	0	0	+	0	0	0	0
P. gregata (All. et Chamb.) W. Gams	0	0	0	0	0	0	0	2.5	0	0
Phlebia gigantea (Fr. Fr.) Donk	0	0	+	0	0	0	0	0	0	0
Pseudogymnoascus roseus Raiłło	0	0	1.0	0	0	1.4	+	0	0	0
Pythium sp.	0	0	0	5.9	0	0	0	0	0	0
Rhizopus nigricans Ehrenberg	0	0	0	+	0	0	0	0	0	0
Sclerophoma pithyophila (Corda) V. Höhn	0	0	0	0	0	1.4	0	0	0	0
Sesquicillium candelabrum (Bonorden) W. Gams	0	0	0	0	0	1.0	+	0	0	0
Sporothrix schenckii Hectoen et Perkins	0	0	0	0	0	2.8	1.2	0	0	4.1
Thysanophora penicillioides (Roum.) Kendr.	+	0	0	0	0	0	0	0	0	0
Tolypocladium geodes W. Gams	0	1.2	0	0	0	1.0	+	0	0	0

Trichocladium asperum Harz	0	0	0	0	0	1.0	0	0	0	0
T. opacum (Corda) S. Hughes	0	0	0	0	0	2.1	0	5.0	1.8	+
Trichoderma sp.	0	0	0	0	0	0	+	0	0	0
T. aureoviride Rifai	+	0	0	0	0	0	0	0	0	0
T. koningii Oudemans	1.1	0	+	9.3	0	1.4	0	0	1.5	0
T. longipilis Bissett	0	0	0	0	0	0	+	0	1.3	1.0
T. polysporum (Link et Pers.) Rifai	0	0	0	+	0	0	0	0	+	+
T. pseudokoningii Rifai	0	1.2	0	0	0	0	0	0	0	0
T. pubescens Bissett	0	0	0	0	0	0	0	0	2.6	0
T. strigosum Bissett	0	0	0	0	0	+	+	0	1.8	1.4
T. virens (Mil. Gidd. et Fost.) von Arx	0	0	0	0	0	0	0	0	0	+
T. viride Pers. ex Fr.	0	0	0	+	0	0	0	0	+	0
Trichosporon beigelii (Kuchenm. et Rab.) Vuill.	0	0	0	4.2	0	0	0	0	0	0
Varicosporium elodeae Kegel	0	0	0	0	0	0	0	0	0	+
Verticillium bulbillosum W. Gams et Malla	0	0	0	0	0	+	0	0	0	0
V. griseum (Petch) W. Gams	0	1.0	+	0	0	0	0	0	0	0
V. lamellicola (F. E. V. Sm.) W. Gams	0	0	3.1	+	0	0	0	0	0	0
Zalerion arboricola Buczacki	0	0	0	0	0	0	0	2.5	0	2.3
Zygorhynchus moelleri Vuill.	0	0	0	0	+	0	2.6	0	1.3	9.1
non-sporulating Br 21	0	+	0	0	0	0	0	0	0	0
non-sporulating Br 28	0	1.4	0	0	0	0	0	0	0	0
non-sporulating Bp 19	0	0	4.1	0	0	0	0	0	0	0
non-sporulating Bp 21	0	0	1.0	0	0	0	0	0	0	0
non-sporulating Bp 22	0	0	1.0	0	0	0	0	0	0	0
non-sporulating Bp 26	0	0	1.0	0	0	0	0	0	0	0
non-sporulating Br 34	0	0	0	0	0	0	+	0	0	0
non-sporulating Bkc 13	0	0	0	0	0	0	0	0	2.0	0
non-sporulating Bkg 3	0	0	0	0	0	0	0	0	0	2.3
non-sporulating Bkg 4	0	0	0	0	0	0	0	0	0	1.4
	97.0	97.9	96.8	95.1	98.3	98.5	96.8	100.0	94.3	95.9
Total number of isolates	888	584	194	237	231	282	2421	40	392	220
Number of species detected	20	27	25	22	10	39	36	14	34	28

+ = species with frequency below 1 %

Table 2

Frequency (%) of the most common taxa in soil, rhizoplane, rhizosphere, fine and thick roots of 30-year-old birch roots

	soil		rhizoplane		rhizosphere		fine roots		thick roots	
	I[x]	II	I	II	I	II	I	II	I	II
Mucorales	45.0	25.7	29.1	48.0	13.4	20.0	56.1	26.5	3.5	19.1
Mycelium radicis atrovirens	0	0	0	0	2.6	0	7.6	18.4	90.5	34.6
Oidiodendron	0	0.7	9.2	0.1	26.8	0	0	0.3	0	0
Penicillium	48.3	51.4	50.6	46.4	39.2	32.5	4.6	27.4	1.3	9.6
Trichoderma	1.8	1.8	1.2	0.2	0.5	0	10.6	7.9	0	3.3

I – live trees
II – stumps

Table 3

Fungal species occurring on/in

live roots – *Absidia glauca* Hagem, *Acremonium apii* (M. A. Sm. & Ramsey) W. Gams, *Acremonium fusidioides* (Nicot) W. Gams, *Aspergillus repens* (de Bary) Fischer, *Aspergillus ruber* Thom & Church, *Beauveria bassiana* (Balsamo) Vuill., *Cylindrocarpon didymum* (Harting) Wollenw., *Exophiala jeanselmai* (Langeron) McGinnis & Padhybe, *Hormiscium* sp., *Humicola grisea* Traaen, *Memnoniella echinata* (Riv.) Galloway, *Mortierella alpina* Peyr., *Mortierella zonata* Linn., *Penicilium aurantiogriseum* Dierckx, *Penicillium citreoviride* Biourge, *Penicillium chrysogenum* Thom, *Penicillium crustosum* Thom, *Penicillium paxilli* Bainier, *Penicilium purpurescens* (Sopp.) Biourge, *Penicillium purpurogenum* Stoll, *Penicillium variabile* Sopp, *Phlebia gigantea* (Fr.ex Fr.) Donk, *Pythium* sp., *Rhizopus nigricans* Ehrenberg, *Trichoderma pseudokoningii* Rifai, *Trichosporon beigelii* (Kuchenm. & Rab.) Vuill., *Verticillium griseum* (Petch) W. Gams, *Verticillium lamellicola* (F. E. V. Sm.) W. Gams, 6 x non-sporulating;

live and stump roots – *Absidia cylindrospora* Hagem, *Aspergillus niveus* Blochwitz, 4 x *Basidiomycotina*, *Botrytis cinerea* Pers, *Chrysosporium merdarium* (L. ex G.) Carm., *Chrysosporium pannorum* (Link) Hughes, *Cladosporium herbarum* Link ex Fr., *Cylindrocarpon destructans* (Zinssm.) Scholten, *Epicoccum nigrum* Link, *Exophiala* sp., *Mortierella gracilis* Linn., *Mortierella humilis* Linn., *Mortierella hygrophila* var. *minuta* Linn., *Mortierella minutissima* van *Tieghem*, *Mortierella nana* Linn., *Mortierella spinosa* Linn., *Mortierella vinacea* Dixon-Stewart, *Mycelium radicis atrovirens* Melin, *Oidiodendron griseum* Robak, *Oidiodendron tenuissimum* (Peck) Hughes, *Penicillium adametzii* Zaleski, *Penicillium citrinum* Thom, *Penicillium commune* Thom, *Penicillium daleae* Zaleski, *Penicillium janczewskii* Zaleski, *Penicillium solitum* Westling, *Penicillium waksmanii* Zaleski, *Pseudogymnoascus roseus* Raillo, *Tolypocladium geodes* W. Gams, *Trichoderma koningii* Oudemans, *Trichoderma polysporum* (Link ex Pers.) Rifai, *Trichoderma viride* Pers. ex Fr., *Zygorhynchus moelleri* Vuill.;

stump roots – *Absidia coerulea* Bainier, *Aspergillus kanagawaensis* Nehira, *Cladosporium* state of *Amorphoteca resinae* Parbery, *Fusarium avenaceurn* (Corda) Sacc., *Gliomastix murorum* var. *felina* (Marchal) Hughes, *Mortierella hygrophila* Linn., *Mortierella isabellina* Oudemans & Koning, *Mortierella microspora* Wolf var. *macrocystis* (Gams) Linn., *Mortierella ramanniana* (Moller) Linn., *Mucor laxorhizus* Ling-Young var. *ovalispora*, *Mucor miehei* Cooney & Emerson, *Penicillium corymbiferum* Westling, *Penicillium lanosum* Westling, *Penicillium raistrickii* G.Sm., *Penicillium spinulosum* Thom, *Penicillium steckii* Zaleski, *Phialophora gregata* (All. & Chainb.) W. Gams, *Sesquicillium candelabrum* (Bonorden) W. Gams, *Sporothrix schenckii* Hectoen & Perkins, *Trichocladium opacum* (Corda) S. Hughes, *Trichoderma longipilis* Bissett, *Trichoderma pubescerns* Bissett, *Trichoderma strigosum* Bissett, *Trichoderma virens* (Mil. Gidd & Fost.) von Arx, *Trichoderma* sp., *Varicosporium elodeae* Kegel, *Zalerion arboricola* Buczacki, 5 x non-sporulating.

Lower rate of decomposition usually results in appearance of many species associated with various stages of decay (H u d s o n, 1968). *Z. moelleri* was absent in both soil beneath the live trees and stumps. The fungus was occasionally detected in the soil beneath the live 49-year-old birches and their stumps (K w a ś n a, 1996 a) and in the soil beneath the maple (W i d d e n, 1979). It however was absent in soil of oak--birch (G o c h e n a u r, 1978), alder (W i c k l o w, W h i t t i n h g a m, 1974) and conifer-hardwood forests (C h r i s t e n s e n, 1969). Its occurrence might be connected with the presence of grasses on the ground surface which is in accordance with C h r i s t e n s e n (1981), who claims that *Z. moelleri* is mostly restricted to grasslands.

The mycobionta on/in roots of stumps of the 30-year-old birches exhibits a greater diversity of species and is more heterogeneous, compared to fungi communities on/in roots of live trees and stumps of the 49-year-old birches (K w a ś n a, 1996 a). This phenomenon was also observed in the roots of Scots pine (K w a ś n a, 1996 b, c). The increase in diversity, like in the soil, is mostly due to the increase in the number of typical saprophytes utilizing the substrates at different stages of decomposition (Table 3). The density and diversity of communities on/in stump roots increased despite the presence of a relatively big population of *Basidiomycotina* which may strongly influence the spectrum of accompanying fungi. The close relationship between the inhibition of hymenomycetous growth and the appearance of "subordinate fungi" was observed by S a i t o (1965). The wood-decaying fungi may release antibiotics as well as certain nutrients from the organic substrate which may selectively benefit the growth of a few species and eliminate most of other.

Many of the most common fungi on/in birch roots, i.e; *Botrytis* sp., *Chrysosporium pannorum*, *Mortierella nana*, *M ramanniana*, *Penicillium daleae*, *P. spinulosum*, *Trichoderma hamatum* group, *T. polysporum*, *T. viride* together with *Basidiomycotina*, *Cylindrocarpon destructans*, *Mycelium radicis atrovirens* and *Oidiodendron tenuissimum*, may decompose cellulose and are considered to be good decomposers of the organic substrate (B ä ä t h, S ö d e r s t r ö m, 1980). *Mortierella vinacea* has such an ability only in the presence of a high level of N sources (D o m s c h et al., 1980). Unlike most *Mortierella*, many *Penicillia* which often formed the dominating group in communities can also degrade cellulose but the decomposition abilities of most of them are not as strong as these exbibited by *P. daleae* and *P. spinulosum*. Due to the decomposition ability of fungi the generic niches based on nutrition preferences may be created. They can be recognised by the occurrence of the certain group of fungi on the organic substrate in the particular stage of its decomposition.

Zygorhynchus moelleri occurred less frequently on/in fine and thick roots of stumps of 30-year-old trees than of 49-year-old birches (K w a ś n a, 1996 a). The fungus accounted for 2.6, 1.3 and 9.1 % of the total number of isolates in the rhizoplane, fine and thick roots of stumps of 30-year-old trees, respectively. Considering the size of the fungal community, in the rhizoplane the density of *Z. moelleri* was high. Before the felling the fungus was present only in the thick roots but its frequency did

not exceed 1 %. It seems that *Z. moelleri* prefers the wood of deciduous stumps rather than that of conifers (K w a ś n a. 1996 a, b, c). Its optimal growth occurs at 25°C (D o m s c h et al., 1980) and this may be the reason for the increase of its population in stands with lower afforestation rate (K w a ś n a, 1996 a) and higher soil temperature which additionally favour the process of decomposition of organic substrate.

Trichoderma viride and *T. virens* occurred rarely or occasionally on/in roots of stumps of 30- and 49-year-old birches (K w a ś n a, l996 a). Other *Trichoderma* spp. which occurred, belonged mostly to the former *T. hamatum* group which is totally ineffective against *Armillaria* (M u g h o g h o, 1968). The results confirm the preference of *T. viride* and *T. virens* for coniferous wood (K w a ś n a, 1996 b, c). *T. viride* requires nitrogen which at low concentration is present in conifferous wood (C o w l i n g, M e r r i l l, 1966). *T. viride* prefers drier habitats (B i s s e t t, P a r k i n s o n, 1979) and higher temperature. Its frequency in pine roots increases after the environmental temperature rises (M a ń k a, G i e r c z a k, 1961). Its density on/in roots of birch in 49-year-old stand (K w a ś n a, 1996 a) was bigger than in the 30-year-old one, though not as big as expected. It seems however, that the size of *T. viride* population depends only to the certain extent on the physical properties of the environment.

Population of *Mycelium radicis atrovirens* increases in fine roots of stumps of the 30- but not of 49-year-old Scots pines, compared to the roots of the live trees (K w a ś n a, 1996 c). In birch the frequency of *M. r. atrovirerrs* increased also only in fine roots of stumps of the 30 year-old trees (K w a ś n a, 1996 a). This may indicate higher vitality of these roots in younger stands. *M. r. atrovirens* is usually a symbiotic species requiring healthy roots of trees growing at suitable sites (M a ń k a, 1960). The bigger population of *Mortierella vinacea* on/in roots of stumps of the 30--year-old birches, than of the 49-year-old trees, supports the hypothesis of the higher vitality of stump roots in younger stand. The fungus dominates in microhabitats with lower rates of decomposition (W i c k l o w et al., 1974) which might be due to the higher moisture and lower temperature of soil. The higher moisture is manifested by the presence of *Varicosporium elodeae* – typical for aquatic habitats (D o m s c h et al., 1980) and the lower temperature by the presence of *Penicillium simplicissimum*, *Tolypocladium* spp. and a bigger number of sterile fungi which are usually very abundant in arctic, antarctic and alpine tundra soils (F l a n a g a n, S c a r b o r o u g h, 1974; B i s s e t t, P a r k i n s o n, 1979, 1979 a; W i d d e n, P a r k i n s o n, 1979; B i s s e t t, 1983).

The population of *Cylindrocarpon destructans* decreased in fine roots and increased in thick roots of stumps. Similar growth of *C. destructans* was observed in the 49-year-old stand (K w a ś n a, 1996 a). On Scots pine stumps its population increased in both types of roots but only in the 30-year-old stand (K w a ś n a, 1996 c). The fungus inhabits young root surfaces but is often isolated also from dead or stump roots (K o w a l s k i, 1980; H o l d e n r i e d e r, S i e b e r, 1992).

According to H u d s o n (1968), in succession of fungi on the organic substrate, *Botrytis cinerea*, *Cladosporium herbarum*, *Epicoccum nigrum* belong to the "primary saprophytes" which follow "parasites". *Basidiomycotina* belong to the "secondary saprophytes" and appear afterwords. The "soil inhabitants" among which Hudson included *Mucorales* occur at the fourth, final stage. The detection of *B. cinerea*, *C. herbarum*, *E. nigrum* and quite big population of *Basidiomycotina* on/in stump roots suggests the second and third stage of fungal succession. The lower increase of *Mucorales* population on/in roots of stumps of the 30-year-old birches, than of the 49-year-old trees (K w a ś n a, 1996 a), additionally suggests lower rate of decomposition of stump roots of younger trees. The roots are presumably not degraded sufficiently to make the colonization by *Z. moelleri* possible. Its occurrence is supposed to be the next step in the fungi succession. In spite of having the ability to decompose hemicellulose, the fungus cannot decompose the cellulose – the main constituent of wood, and thus must colonize the wood as the last species (B ä ä t h, S ö d e r s t r ö m, 1980).

Conclusions. The present study indicates that the rate of decomposition of roots of 2-year-old stumps of the 30-year-old birches does not favour their colonization by *Z. moelleri* and its presumable contribution in enhancing the infection by *Armillaria* might not be so distinct as on stumps of the 49-year-old birch trees.

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Mikobionty korzeni brzozy oraz korzeni jej pniaków i ich przypuszczalny wpływ na porażenie przez *Armillaria* spp. II.

Streszczenie

Praca przedstawia różnice w wielkości i strukturze zbiorowisk grzybowych w glebie, na powierzchni i w korzeniach pniaków 30-letnich brzóz w dwa lata po ich ścięciu. Zbiorowisko grzybów w glebie pod pniakami było trzykrotnie mniejsze od podobnego zbiorowiska pod żywymi drzewami. W 2 lata po ścięciu drzew wzrost liczby grzybów nastąpił w korzeniach cienkich oraz w ich ryzoplanie, spadek natomiast w ryzosferze. Liczba grzybów w korzeniach grubych pozostała bez zmian. W porównaniu z drzewami żywymi, w ogromnej większości przypadków, zbiorowiska z pniaków zawierały wiekszą liczbę gatunków i były bardziej urozmaicone. *Zygorhynchus moelleri* stanowił 2,6; 1,3 i 9,1 % ogólnej liczby izolatów z ryzoplany, korzeni cienkich i korzeni grubych pniaków. Tylko pojedyncze izolaty *Trichoderma viride* i *T. virens* stwierdzano w zbiorowiskach z korzeni cienkich i grubych pniaków. Wzrost populacji grzyba *Mycelium radicis atrovirens* sugeruje stosunkowo dużą witalność korzeni cienkich u pniaków 30-letnich brzóz. Struktura zbiorowisk z gleby, a w szczególności z korzeni, sugeruje niższy stopień rozkładu korzeni pniaków w drzewostanie 30-letnim niż w 49-letnim. Wydaje się, że po upływie 2 lat stopień rozkładu korzeni brzozowych w drzewostanie 30-letnim nie sprzyja kolonizacji przez *Z. moelleri*, a jego domniemany udział w stymulowaniu porażenia przez *Armillaria* będzie mniejszy niż w drzewostanie 49-letnim.