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THE PROBLEM OF ROOT ROT *FOMES ANNOSUS* (FR.) CKE AGAINST A BACKGROUND OF THE FUNGAL COMMUNITIES IN THE FOREST SOIL

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INTRODUCTION

The problem of root rot in Poland is becoming increasingly important in view of the extensive afforestation of marginal lands. In spite of the fact that this disease is being studied throughout the world by many scientists, the problem is permanently with us and in view of its complexity requires a constant scientific effort in order to find a way of solving it. Presently increasingly frequently the effort is being concentrated on the study of biological methods of fighting the disease [1, 7, 8, 12, 14, 15, 16, 17, 23, 24, 25, 26] and on the search for varieties resistant to *F. annosus* [5, 9, 27]. Besides the generally recognized method in which the disease spreads, primarily through stumps left after fellings followed by a contact of the diseased roots with the healthy ones, some authors are pointing out that there exists also a possibility of infecting thin roots straight from the soil [2, 21] and even through a phase of ectotrophic mycorrhizae [21, 10] *.

Taking into consideration the possibility of *Fomes annosus* infecting fine roots, one has to attach greater significance to the possibility of controlling the disease with biological methods by affecting the communities of microorganisms in the soil. This requires more studies on the effect of these communities on the growth and development of the fungus *Fomes annosus*.

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* The author is obliged to note, that at the end of his paper of 1970 he cited erroneously an article of Orsłoś and Dominik [21] ascribing Dominik the presentation of a peritrophic mycorrhiza *Pinus sylvestris* × *Fomes annosus*. In fact Dominik, basing on unpublished data of J. Zub, described there not a peritrophic but an ectotrophic mycorrhiza formed by the organisms mentioned. The author profoundly bags pardon as well of prof. Dominik as of dr. Zub.

MATERIALS AND METHODS

For the investigation two 50 year old pine stands have been selected, stand 1 being seriously affected by *F. annosus*, while stand 2 was in an area in which infection by this pathogen has not been observed. Stand 1 was phytosociollogically within the subassociation *Leucobryo-Pinetum molinietosum* [18, 19] while stand 2 within the subassociation *Leucobryo-Pinetum clodonietosum*. A soil analysis has shown that stand 1 grows on a soil of the podsol group, moderately podsolized, formed from fluvioglacial deposits, with a pH of 4.35 in the A_1 horizon. In both the stands six 4 acre plots have been selected from which at monthly intervals mycorrhizal samples were taken for analysis from April to December of two successive years, taking at least 10 samples from various points on each plot. Besides in both the stands, once during Autumn samples were taken for mycological analysis of the litter in the A_0F horizon, of the soil from the A_1 horizon and of fine pine roots (up to 1 mm in diameter).

The mycorrhizae have been collected according to the general methods described by Dominik [3]. After selecting out and describing the various morphological types of the mycorrhizae they were split into two lots, one of which was left for further anatomical studies aimed at determining the genus of mycorrhiza [4] and the other was used for the isolation of fungi comprising the mycorrhiza. Mycorrhizae, from which isolated fungi have been subjected first to an accurate purification (under a binocular) and then each morphological type was individually surface sterilized according to the general method of Harley and Waid [6] using agitation in 11 succesive flasks [12] 9 of which contained 70 ml of distilled and sterilized water, the 10th containing 70 ml of distilled sterile water and 30 g of sterile quartz sand and the 11th flask having similarily as the first nine 70 ml on sterile distilled water. The time of agitation of each washing was 3 min using 140 shakes per min. After taking the mycorrhizae from the 11th washing they were divided into 4 parts. One part was dried in sterile filter paper and placed singly onto a medium previously prepared in Petri dishes, four samples per dish. The second part was additionally disinfected with 96% ethanol for 2 seconds, the third with 0.1% mercuric chloride for 3-4 seconds, and the fourth part with 10% quinosol for 30 sec. After chemical sterilization the mycorrhizae have been washed in three successive changes of sterile distilled water, 3 min in each, and then dried in sterile filter paper and placed 6 per Petri dish onto a Melin and Rama Das medium [20] with the following vitamins added in quatities expressed per 1000 ml of the medium; tiamine 100 µg, biotine 5 µg, pyrodoxin 100 µg, amide of nicotinic acid 5 mg. Isolation of fungi from the mycorrhizae from stand 1 has been performed from 48 morphological types, belonging to 9 genera of mycorrhizae, using for

the isolation 1920 Petri dish replicates. From stand 2 20 morphological types were used belonging to 8 genera of mycorrhizae, using for the isolation 800 Petri dish replications in all. Incubation was performed at a temperature of 24°C and the colonies of fungi growing out of the inocula have been transferred into test-tubes with potato-glucose agar slants.

In order to establish which fungi isolated from the mycorrhizae are capable of establishing a mycorrhizal relationship, tests were made of the artificial syntesis of these fungi with the roots of pine seedlings according to the method of Pachlewska [22] as described earlier [10].

Fungi from the soil have been isolated by the method described by Mańka [11].

Fungi from the litter have been isolated by the method described by Mańka and Gierczak [13] with the difference that from the whole evenly mixed sample of the litter six 0.5 g subsamples were taken each of which was distributed individually in a flask containing up to 149.5 g of sterile quartz sand.

When working on the root samples, in one sequence of isalations first the rhizospheric fungi were obtained, and then the fungi anatomically associated with the roots, using the method described by Mańka [15] however the rhizospheric fungi have been analysed from the 2nd and the 9th washing only.

Fungi from the soil, litter, roots and rhizosphere have been isolated using 60 Petri dish replicates in each case. These were incubated at a temperature of 24°C and the fungal colonies observed on them have been transferred into test-tubes and later described and identified. The isolates of fungi from the various groups were joined into fungal communities and the function of these associations in relation to the fungus *F. annosus* has been evaluated using for the purpose the method of biotic series as proposed by Mańka [12, 15]. For the purpose from various fungal associations of the studied soil community 15 most commonly occurring fungal species were selected which represented not less than 70% of all the isolates. Each of these fungi has been studied from the point of view of its effect on the growth of the fungus *F. annosus* (cultures of two organisms). In the case of fungi isolated from the mycorrhizae those isolated from one genus of mycorrhizae have been treated as a community, and the summary biotic effects refer to such communities. This approach appears justified in the assumption that it is not single mycorrhizal fungi but complexes of them that provide defence for root systems against phytopathogenic organisms.

RESULTS

Among the mycorrhizae collected during the studies 9 genera of *Pinus sylvestris* mycorrhizae have been found in stand 1 (Ad, Be, Ca, Cb, Fb,

Fd, Ff, Ga, Ja) and 8 genera in stand 2 (Ad, Bb, Be, Cc, Fb, Ga, Ha, Ja). The following genera were associated exclusively with stand 1: Ca, Cb, Fd, and Ff while those associated exclusively with stand 2 were: Bb, Cc, Ha. Simultaneously in both stands there were genera: Ad, Be, Fb, Ga, and Ja. From pine mycorrhizae of boht the stands in all 37 species of fungi were isolated (Table 1) of which 24 species belong to the class *Basidiomycetes* and to not sporulating fungi (may be also *Basidiomycetes*).

It can be seen from Table 1 that with the mycorrhizae in stand 1 there were 20 fungal species associated exclusively, while with stand 2 there were 4. The remaining 13 species were associated with pine mycorrhizae both in stand 1 and in stand 2. It needs to be emphasized that usually from one genus of mycorrhiza more than one fungal species was isolated. Also from different samples of the same genera of mycorrhizae in both stands different combinations of fungi were isolated.

From the soil, litter, pine roots and the rhizosphere of both the stands, in all 4968 isolates were obtained of fungi belonging to 172 species. Quantitative and qualitative occurrence of these fungi in individual communities is presented in Table 2.

From the data presented in Table 2 it can clearly be seen that the two stands differed profoundly in the qualitative and quantitative composition of the soil fungal community. The greatest differentiation of the fungal species in both the stands was demonstrated by the community of rhizospheric fungi, while the lowest variation was demonstrated by the community of root fungi and of mycorrhizal fungi (Tables 1 and 2).

With the help of this differentiated structure of soil fungal communities in the two stands an attempt was made to determine the degree to which the stands are endangered by the pathogenic fungus *Fomes annosus*, using for the purpose the method of biotic series proposed by Mańka [15]. Results of studies on the effect of the forest soil fungal community on the growth of the fungus *F. annosus* is presented in Tables 3 to 8. Positive values of the presented biotic effects indicate that individual fungi of the soil community have limited the growth of the fungus *F. annosus* while the negative values indicate that they have favoured the growth of the pathogen.

As can be seen from the presented tables the fungal communities from stand 1 have favoured the growth of *Fomes annosus* to a much greater extent than the fungal communities in stand 2. The most diverse joint biotic effects were observed in the case of fungal communities from the litter (horizon A_0F), rhizosphere and mycorrhizae. Fungal communities from all the genera of mycorrhizae in stand 1, except genus „Ja", have had a negative biotic effect in relation to *F. annosus*. This may indicate that these fungal communities have low protective value to pine roots against *F. annosus*. The fungal communities from the various genera of

Table 1

Fungi isolated from *Pinus sylvestris* mycorrhizae

Fungal species	Genus of mycorrhiza	
	stand 1	stand 2
Basidiomycetes sp. I	Ad, Cb, Fd	Ad
Basidiomycetes sp. II	Fb	Fb
Basidiomycetes sp. III	Ad	—
Basidiomycetes sp. IV	Ad	—
Basidiomycetes sp. V	Be	—
Basidiomycetes sp. VI	Ja	Ja
Cephalosporium acremonium	Be, Ja	—
Cephalosporium charticola	Ad, Cb, Fd	Ad, Be
Cephalosporium glutineum	Be, Fd	Ad, Bb, Be
Fusidium terricola	Be, Fd	—
Hormodendrum elatum	Be, Cb, Fd, Ja	—
Hormodendrum hordei	—	Ja
Hormodendrum microsporum	Cb, Fd, Ff	—
Hormodendrum microsporioides	Ad, Be, Ca, Fd, Ff	Ad
Hormodendrum nigricans	Ad, Ca, Fd	—
Mortierella humilis	Be, Fd, Ja	Cc
Mortierella isabellina	Ad	—
Mycelium radicis atrovirens I	Ad, Be, Ca, Cb, Fb Fd, Ff, Ga, Ja	Ad, Cc, Ga
Mycelium radicis atrovirens II	Be, Cb, Fd	Cc, Fb, Ha
Oidiodendron griseum	Ca	—
Paecilomyces farinosus	Fd, Ja	—
Not sporulating KM2	—	Ha
,, ,, KM5	—	Cc
Not sporulating KM7	Ad, Be, Cb, Fb, Fd Ff	Ad, Cc, Fb
,, ,, KM8	Be	Be
Not sporulating KM12	—	Cc
Not sporulating KM23	Ad, Be, Cb, Fd, Ff	Cc, Fb, Ga
,, ,, SM2	Ad, Be, Ca, Cb, Fd, Ff, Ja	—
,, ,, SM10	Be	—
,, ,, SM21	Be	—
,, ,, SM33	Fd	—
Not sporulating SM35	Fd	Fb
,, ,, SM37	Cb	—
,, ,, SM57	Ca	—
,, ,, SM58	Ad, Ca, Fb, Fd, Ff, Ja	—
,, ,, SM156	Fd	Ad
,, ,, SM157	Fd	—
,, ,, SM172	Be	—

Explanations: The fungi which are underlined gave typical ectotrophic mycorrhizae in artificial syntheses with *Pinus sylvestris* roots (more data on the subject in a separate publication which is in print).

Table 2

Fungi isolated from the soil environment

Fungal species	Number of fungal isolates							
	stand 1				stand 2			
	G	*S*	*R*	*K*	*G*	*S*	*R*	*K*
1	2	3	4	5	6	7	8	9
Absidia butleri Lendner	—	—	—	—	—	—	—	3
Absidia glauca Hagem	—	—	—	14	—	25	14	—
Absidia orchidis (Vuillemin) Hagem	—	32	1	—	—	—	—	44
Absidia spinosa Lendner	1	46	4	23	—	—	—	—
Actinomycetes sp. 1	1	—	—	—	—	—	—	—
Aspergillus carneus (van Tiegh) Blochwitz	7	—	—	—	—	—	—	—
Aspergillus flavus Link	1	2	—	—	—	—	2	—
Aspergillus fumigatus Fresenius	—	—	1	—	—	—	—	—
Aspergillus ustus (Bainier) Thom et Church	1	—	—	—	—	—	—	—
Aspergillus versicolor (Vuill.) Tirabo.	5	2	17	—	2	—	23	—
Aspergillus sp. (Candidus gr.)	—	4	4	—	—	—	—	—
Basidiomycetes sp. KRJ383	—	—	—	—	—	—	1	—
Basidiomycetes sp. KRJ799	—	—	—	—	—	—	1	—
Beauveria bassiana (Bal.) Vuill.	2	1	2	—	—	—	5	—
Beauveria brongiartii (Sacc.) Petch	5	1	11	—	—	—	—	—
Botryotrichum Sacc. et Marchal sp. 1	4	—	—	—	—	—	—	—
Botrytis cinerea Persoon	—	—	—	—	1	—	4	—
Botrytis pyramidalis (Bonordеn) Sacc.	—	—	—	—	—	—	1	—
Calcarisporium arbuscula Preuss	—	—	1	—	—	—	—	—
Candida lipolytica (Harr.) Didd. et Lodd.	—	—	—	—	—	—	2	—
Catenularia fuliginea Saito	4	—	—	—	—	—	—	—
Cephalosporium acremonium Corda	—	—	2	—	—	—	—	1
Cephalosporium bonordenii Sacc.	—	3	5	—	2	—	3	—
Cephalosporium glutineum Kamyschko	—	6	1	—	—	4	10	—
Cephalosporium charticola Lindau	—	—	6	—	—	—	2	—
Chaetomium indicum Corda	—	—	1	—	—	—	—	—
Cirrhomyces caudiger Höhnel	—	4	—	—	—	—	—	—
Cladosporium herbarum (Pers.) Link ex Fries	3	1	3	—	2	2	2	—
Gliocladium fimbriatum Gilm. et Abbott	—	10	—	—	5	—	—	—
Coniothyrium fuckelii Saccardo	—	—	—	1	1	—	2	—
Dicoccum asperum Corda	1	—	—	—	—	—	—	—
Fusarium oxysporum var. *longius* Sherb.	—	—	—	1	—	—	—	—
Fusidium terricola Miller	—	—	24	4	—	—	6	—
Fusidium Link ex Fries sp. 1	—	—	—	—	2	—	—	—
Geotrichum Link ex Persoon sp. 1	—	—	—	—	1	—	—	—
Gloeosporium Desm. et Mont. sp. 1	—	—	2	—	—	—	—	—
Gymnoascus setosus Eidam	2	2	—	—	—	—	—	—
Haplographium flexuosum (Preuss) Sacc.	—	—	—	—	1	—	—	—

Table 2 continued

1	2	3	4	5	6	7	8	9
Hormodendrum cladosporioides (Fres.) Sacc.	1	—	—	—	18	—	—	—
Hormodendrum elatum Harz	—	—	8	—	60	—	—	—
Hormodendrum microsporioides Mańka et Truszkowska	6	2	99	—	30	6	23	—
Hormodendrum olivaceum (Corda) Bonor.	267	27	15	—	9	3	11	—
Hughesiella Batista et Vital. sp. 1	—	—	—	—	2	—	—	—
Humicola fuscoatra Traaen	2	—	—	—	1	—	—	—
Lacellina Saccardo sp. 1	5	—	2	—	—	9	12	—
Masoniella grisea (G. Smith) G. Smith	1	—	—	—	—	—	—	—
Masoniella G. Smith sp. 1	6	1	—	—	—	—	—	—
Monocillium humicola Barron	—	5	—	—	—	—	—	—
Monocillium humicola v. *humicola* Barron	—	—	6	—	—	—	—	—
Monocillium humicola v. *brunneum* Christ. et Backus	—	—	1	—	—	—	—	—
Mortierella gracilis Linnemann	—	2	1	—	—	—	—	2
Mortierella humilis Linnemann	—	1	—	1	—	—	4	14
Mortierella isabellina (Oudem.) Zycha	3	25	3	10	6	14	15	14
Mortierella marburgensis Linnemann	—	—	—	1	—	—	—	2
Mortierella nana Linnemann	2	—	—	—	104	—	—	—
Mortierella parvispora Linnemann	2	5	1	—	—	—	—	—
Mortierella rammaniana (Moeller) Linn.	—	1	1	—	—	—	—	—
Mortierella rammaniana var. *angulispora* (Naumov) Linn.	—	—	—	—	—	1	—	—
Mortierella vinacea Dixon—Stewart	1	—	—	5	—	—	2	27
Mucor fragilis Bainier	—	—	—	—	4	1	—	—
Mucor hiemalis Wehmer	—	1	—	—	—	—	—	—
Mycelium radicis atrovirens Melin	—	—	5	178	—	—	3	112
Oidiodendron cerealis (Thümen) Barron	7	—	32	—	—	—	—	—
Oidiodendron echinulatum Barron	—	—	—	—	—	—	6	—
Oidiodendron gracile Zhdanova	—	—	—	—	3	—	—	—
Oidiodendron griseum Robak	4	—	4	—	8	1	9	—
Oidiodendron rhodogenum Robak	—	—	—	—	1	—	—	—
Oidiodendron tenuissimum (Peck) Hughes	—	—	—	—	—	5	—	—
Oidiodendron trunctatum Barron	—	—	5	—	—	—	—	—
Oospora variabilis (Lindner) Lindau	—	—	1	—	1	—	—	—
Paecilomyces carneus (Duchè et Heim) Brown et Smith	—	—	—	—	—	1	—	—
Paecilomyces farinosus (Dicks. ex Fr.) Brown et Smith	—	—	—	—	—	—	10	—
Penicillium adametzi Zaleski	—	94	—	1	—	9	2	26
Penicillium albidum Sopp	—	—	3	—	—	—	—	—
Penicillium canescens Sopp	—	—	—	—	—	2	2	—
Penicillium citrinum Thom	—	9	1	2	—	—	1	—
Penicillium chermesinum Biourge	7	—	1	—	4	3	121	16
Penicillium chrysogenum Thom	2	—	—	—	—	—	—	—

Table 2 continued

1	2	3	4	5	6	7	8	9
Penicillium corylophilum Dierckx	—	—	1	—	—	3	—	—
Penicillium cyaneum B. et S. Biourge	—	—	—	—	7	—	—	—
Penicillium decumbens Thom	7	181	61	32	44	27	101	7
Penicillium fellutanum Biourge	25	—	—	—	—	2	—	7
Penicillium frequentans Westling	—	—	—	2	—	—	2	—
Penicillium funiculosum Thom	—	—	—	—	—	2	2	—
Penicillium godlewskii Zaleski	1	—	—	—	—	—	—	—
Penicillium granulatum Bainier	—	—	—	—	—	—	4	—
Penicillium implicatum Biourge	—	9	—	—	—	—	—	—
Penicillium islandicum Sopp	—	—	—	—	—	—	3	—
Penicillium jenseni Zaleski	1	172	33	44	—	6	9	7
Penicillium lanosum Westling	—	17	6	—	—	6	—	11
Penicillium lividum Westling	—	29	—	—	—	—	—	—
Penicillium luteum Zukal	—	—	6	—	—	—	—	—
Penicillium miczynskii Zaleski	—	1	7	1	—	—	—	—
Penicillium multicolor Grigorieva-Moroilova	—	2	—	—	—	—	—	—
Penicillium nigricans (Bainier) Thom	5	—	1	—	—	—	—	—
Penicillium oxalicum Currie et Thom	—	—	—	—	—	1	—	—
Penicillium paxilli Bainier	—	1	—	2	—	—	—	—
Penicillium piscarium Westling	—	—	—	—	—	—	15	—
Penicillium raistrickii Smith	—	1	—	—	—	—	—	—
Penicillium restrictum Gilman et Abbott	1	24	—	11	12	—	—	2
Penicillium rolfsii Thom	—	—	—	—	—	1	2	1
Penicillium roqueforti Thom	—	—	—	—	—	—	3	—
Penicillium roseo-purpureum Dierckx	6	—	5	—	—	—	6	—
Penicillium rugulosum Thom	—	—	1	—	—	—	1	—
Penicillium spinulosum Thom	51	183	28	38	102	216	188	155
Penicillium steckii Zaleski	—	1	—	—	—	9	—	—
Penicillium stoloniferum Thom	1	—	—	6	—	—	39	—
Penicillium tardum Thom	—	3	—	—	—	1	16	—
Penicillium terlikowskii Zaleski	3	5	—	3	—	1	—	1
Penicillium thomii Maire	—	1	—	—	—	—	2	—
Penicillium variabile Sopp	—	—	2	—	—	—	4	—
Penicillium velutinum van Beyma	7	2	—	—	4	—	—	—
Penicillium vinaceum Gilman et Abbott	6	—	—	—	—	—	—	—
Penicillium waksmani Zaleski	3	8	—	—	—	—	—	—
Penicillium Link sp. 1	—	4	—	—	—	—	—	—
Scopulariopsis Bainier sp. 1	—	—	—	—	1	1	—	—
Scopulariopsis Bainier sp. 2	—	—	—	—	—	—	17	1
Scopulariopsis constantini Bainier	—	—	—	—	—	—	1	—
Sporotrichum pulviniforme Thürm	6	2	—	—	—	—	—	—
Septonema secedens Corda	—	—	2	—	—	—	—	—
Stachylidium extore var. *majus* Saccardo	—	—	2	—	—	—	—	—
Stysanus medius Saccardo	1	—	—	—	16	—	—	—
Stysanus Corda sp. 1	3	—	—	—	5	—	—	—
Tilachlidium microsporum Kamyschko	—	—	1	—	—	—	1	—
Tilachlidium ramosum (Mains) Mains	1	—	3	—	—	—	—	—

Table 2 continued

1	2	3	4	5	6	7	8	9
Trichoderma album Preuss	6	7	3	—	—	—	—	—
Trichoderma glaucum Abbott	6	13	—	39	—	82	—	—
Trichoderma lignorum (Tode) Harz	8	127	—	63	22	54	31	55
Trichoderma koningi Oudemans	16	12	3	19	3	7	18	49
Trichosporium berengerianum Saccardo	4	—	—	—	1	—	—	—
Trichosporium contaminans Oudemans	5	2	4	—	—	—	—	—
Verticillium capitatum Ehrenb.	20	3	5	—	—	—	—	—
Not sporulating Sg 22	1	—	—	—	—	—	—	—
,, ,, Sg 201	1	—	—	—	—	—	—	—
Not sporulating Sg237	2	—	—	—	—	—	—	—
,, ,, Sg292	1	—	—	—	—	—	—	—
,, ,, Sg 382	1	—	—	—	—	—	—	—
,, ,, Sg561	1	—	—	—	—	—	—	—
,, ,, KgJ47	—	—	—	—	1	—	—	—
,, ,, KgJ65	—	—	—	—	1	—	—	—
,, ,, KgJ143	—	—	—	—	1	—	—	—
,, ,, KgJ304	—	—	—	—	1	—	—	—
,, ,, KgJ320	—	—	—	—	1	—	—	—
,, ,, KgJ364	—	—	—	—	2	—	—	—
,, ,, KgJ397	—	—	—	—	1	—	—	—
,, ,, Ss20	—	1	—	—	—	—	—	—
,, ,, Ss138	—	1	—	—	—	—	—	—
,, ,, Ss774	—	2	—	—	—	—	—	—
,, ,, Ss935	—	1	—	—	—	—	—	—
,, ,, Ks 421	—	—	—	—	—	1	—	—
,, ,, SRJ34	—	—	2	—	—	—	—	—
,, ,, SRJ51	—	—	1	—	—	—	—	—
,, ,, SRJ54	—	—	1	—	—	—	—	—
,, ,, SRJ56	—	—	1	—	—	—	—	—
,, ,, SRJ57	—	—	1	—	—	—	—	—
,, ,, SRJ63	—	—	1	—	—	—	—	—
,, ,, SRJ87	—	—	2	—	—	—	—	—
,, ,, SRJ105	—	—	1	—	—	—	—	—
,, ,, SRJ217	—	—	1	—	—	—	—	—
,, ,, SRJ263	—	—	14	—	—	—	—	—
,, ,, SRJ344	—	—	2	—	—	—	—	—
,, ,, SRJ359	—	—	1	—	—	—	—	—
,, ,, SRJ360	—	—	1	—	—	—	—	—
,, ,, KRJ21	—	—	—	—	—	—	1	—
,, ,, KRJ490	—	—	—	—	—	—	1	—
,, ,, KRJ671	—	—	—	—	—	—	1	—
,, ,, SKJ58	—	—	—	1	—	—	—	—
,, ,, SKJ71	—	—	—	4	—	—	—	—
,, ,, SKJ102	—	—	—	1	—	—	—	—
,, ,, SKJ200	—	—	—	1	—	—	—	—
,, ,, SKJ338	—	—	—	1	—	—	—	—
,, ,, KM7	—	—	—	—	—	—	—	1
Total of fungal isolates	553	1102	477	509	493	506	767	558
Number of fungal species and forms	58	54	66	29	41	32	53	23

Explanations: *G* — soil, *S* — litter, *R* — rhizosphere, *K* — roots.

Table 3

Effect of fungal communities isolated from various genera of *Pinus sylvestris* mycorrhizae in stand 1 on the growth of the fungus *Fomes annosus*

Mycorrhizae		Fungal species	Biotic effect	
Genus	Frequency		individual	joint
1	2	3	4	5
Ad	+ + +	*Basidiomycetes* sp. I	−5	−26
		Basidiomycetes sp. III	+5	
		Basidiomycetes sp. IV	−3	
		Cephalosporium charticola	+10	
		Hormodendrum microsporioides	−2	
		Hormodendrum nigricans	−4	
		Mortierella isabellina	−3	
		Mycelium radicis atrovirens strain I	−6	
		Not sporulating SM2	−7	
		,, ,, SM58	+1	
		,, ,, KM7	−6	
		,, ,, KM23	−6	
Be	+ + +	*Basidiomycetes* sp. V	−4	−8
		Cephalosporium glutineum	+20	
		Cephalosporium acremonium	+23	
		Fusidium terricola	−4	
		Hormodendrum elatum	−4	
		Hormodendrum microsporioides	−2	
		Mortierella humilis	+4	
		Mycelium radicis atrovirens strain I	−6	
		Mycelium radicis atrovirens strain II	−5	
		Not sporulating SM2	−7	
		,, ,, SM10	−5	
		,, ,, SM21	+5	
		,, ,, SM172	−7	
		,, ,, KM7	−6	
		,, ,, KM8	−4	
		,, ,, KM23	−6	
Ca	+ + +	*Hormodendrum microsporioides*	−2	−7
		Hormodendrum nigricans	−4	
		Mycelium radicis atrovirens strain I	−6	
		Not sporulating SM2	−7	
		,, ,, SM57	+8	
		,, ,, SM58	+1	
		Oidiodendron griseum	+3	
		Basidiomycetes sp. I	−5	
		Cephalosporium charticola	+10	
		Hormodendrum elatum	−4	
		Hormodendrum microsporum	−2	

Table 3 continued

1	2	3	4	5
		Mycelium radicis atrovirens strain I	−6	
Cb	+ + +	*Mycelium radicis atrovirens* strain II	−5	−34
		Not sporulating SM2	−7	
		,, ,, SM37	−3	
		,, ,, KM7	−6	
		,, ,, KM23	−6	
		Basidiomycetes sp. II	−5	
		Mycelium radicis atrovirens strain I	−6	
Fb	+ +	Not sporulating SM58	+1	−16
		,, ,, KM7	−6	
		Basidiomycetes sp. I	−5	
		Cephalosporium charticola	+10	
		Cephalosporium glutineum	+20	
		Fusidium terricola	−4	
		Hormodendrum elatum	−4	
		Hormodendrum microsporioides	−2	
		Hormodendrum microsporum	−2	
		Hormodendrum nigricans	−4	
		Mortierella humilis	+4	
Fd	+ + +	*Mycelium radicis atrovirens* strain I	−6	−12
		Mycelium radicis atrovirens strain II	−5	
		Not sporulating SM2	−7	
		,, ,, SM33	+2	
		,, ,, SM35	+7	
		,, ,, SM58	+1	
		,, ,, SM156	−2	
		,, ,, SM157	−5	
		,, ,, KM7	−6	
		,, ,, KM23	−6	
		Paecilomyces farinosus	+2	
		Hormodendrum microsporioides	−2	
		Hormodendrum microsporum	−2	
		Mycelium radicis atrovirens strain I	−6	
Ff	+ +	Not sporulating SM2	−7	−28
		,, ,, SM58	+1	
		,, ,, KM7	−6	
		,, ,, KM23	−6	
Ga	+ +	*Mycelium radicis atrovirens* strain I	−6	−6

Table 3 continued

1	2	3	4	5
		Basidiomycetes sp. VI	+6	
		Cephalosporium acremonium	+23	
		Hormodendrum elatum	—4	
Ja	+	*Mortierella humilis*	+4	+19
		Mycelium radicis atrovirens strain I	—6	
		Not sporulating SM2	—7	
		„ „ SM58	+1	
		Paecilomyces farinosus	+2	

mycorrhizae from stand II have had either a positive or a negative joint biotic effect on *Fomes annosus*, however the negative values taken jointly (as an algebraic sum called also „summary biotic effect") was much lower than in stand 1. From Tables 3 and 4 it can further be seen, that the same genera of mycorrhizae depending on the community from which they came have had a different joint biotic effect. Joint biotic effects of the mycorrhizae genera Ad, Be, Ja have had a negative value in one stand and positive ones in the other. This was the result of the individual fungal components being different for these mycorrhizae coming from different stands, which is probably a reflection on the differences in the overall soil environment of the microorganisms.

From Tables 3 to 8 it can also be deduced that there is a considerable difference between strains of fungal species in the effect they have on the growth of *Fomes annosus*. This differentiation was in extremal cases in *Cephalosporium glutineum* from —2 to +20, in *Cephalosporium charticola* from —3 to +10, in *Penicillium lanosum* from —5 to +5, in *P. spinulosum* from —6 to +1, in *P. rastrictum* from —5 to +2, in *P. jenseni* from —6 to +1, in *Oidiodendron griseum* from —4 to +3. The greatest differentiation of the individual biotic effects was observed between strains of the same fungus isolated from the mycorrhizae and the same strains isolated from other parts of the soil environment, such as from the soil itself, from the rhizosphere, from the roots or from the litter. Exceptionally strong antibiotic effect on the fungus *Fomes annosus* has been demonstrated by the fungi *Cephalosporium acremonium* (biotic effect +23) and *Cephalosporium glutineum* (biotic effect +20) isolated from the mycorrhizae.

Table 4

Effect of fungal communities isolated from various genera of *Pinus sylvestris* mycorrhizae in stand 2 on the growth of the fungus *Fomes annosus*

Mycorrhizae		Fungal species	Biotic effect	
Genus	Frequency		individual	joint
Ad	+ + +	*Basidiomycetes* sp.I	−4	+9
		Cephalosporium charticola	+10	
		Cephalosporium glutineum	+18	
		Hormodendrum microsporioides	−2	
		Mycelium radicis atrovirens strain I	−6	
		Not sporulating KM7	−4	
		,, ,, SM156	−3	
Bb	+ + +	*Cephalosporium glutineum*	+18	+18
Be	+ +	*Cephalosporium glutineum*	+18	+24
		Cephalosporium charticola	+10	
		Not sporulating KM8	−4	
Cc	+ + + +	*Mortierella humilis*	+4	−19
		Mycelium radicis atrovirens strain I	−6	
		Mycelium radicis atrovirens strain II	−5	
		Not sporulating KM5	−5	
		,, ,, KM7	−4	
		,, ,, KM12	+1	
		,, ,, KM23	−4	
Fb	+ + +	*Basidiomycetes* sp. II	−5	−11
		Mycelium radicis atrovirens strain II	−5	
		Nor sporulating KM7	−4	
		,, ,, KM23	−4	
		,, ,, SM35	+7	
Ga	+ +	*Mycelium radicis atrovirens* strain I	−6	−10
		Not sporulating KM23	−4	
Ha	+ +	*Mycelium radicis atrovirens* strain II	−5	−9
		Not sporulating KM2	−4	
Ja	+ +	*Basidiomycetes* sp. VI KM34	−1	−3
		Hormodendrum hordei	−2	

Explanations for Tables 3 and 4:

\+ very rare occurrence (up to 1% of tested mycorrhizae)
\+ + rare occurrence (2—5% of tested mycorrhizae)
\+ + + frequent occurrence (6—10% of tested mycorrhizae)
\+ + + + very frequent occurrence (abovo 10% of tested mycorhizae).

Table 5

The effect of the fungi isolated from the litter in the studied stands on the growth of fungus *Fomes annosus*

Fungal species	Stand 1			Stand 2		
	No. of fungal isolates	biotic effect		No. of fungal isolates	biotic effect	
		individual	joint		individual	joint
Absidia glauca	—	—	—	25	+4	+100
Absidia orchidis	32	+5	+160	—	—	—
Absidia spinosa	46	—5	—230	—	—	—
Cephalosporium glutineum	—	—	—	4	—2	—8
Gliocladium fimbriatum	10	+7	+70	—	—	—
Hormodendrum microsporioides	—	—	—	6	—5	—30
Hormodendrum olivaceum	27	—5	—135	—	—	—
Lacellina sp. 1	—	—	—	9	—5	—45
Mortierella isabellina	25	—3	—75	14	—5	—70
Oidiodendron tenuissimum	—	—	—	4	—5	—20
Penicillium adametzi	94	—4	—376	9	—7	—63
Penicillium decumbens	181	—4	—724	27	—4	—108
Penicillium jenseni	172	+1	+172	6	+1	+6
Penicillium lanosum	17	—5	—85	6	—3	—18
Penicillium lividum	29	+3	+87	—	—	—
Penicillium restrictum	24	—5	—120	—	—	—
Penicillium spinulosum	183	—4	—732	216	+2	+432
Penicillium steckii	—	—	—	9	—4	—36
Trichoderma glaucum	13	+7	+91	82	+7	+574
Trichoderma lignorum	127	+7	+889	54	+7	+378
Trichoderma koningi	12	+7	+84	7	+7	+49
Total	992		—924	478		+1141

Explanation: The number of fungal isolates in stand 1 is 992 which represents 90,0% of the total number of isolates. The summary biotic efect is —924. The total number of fungal isolates in stand 2 was 478 which represents 94,5% of the total number of isolates. The summary biotic effect is +1141.

Table 6

The effect of fungal isolates from the soil in the studied stands on the growth of fungus *Fomes annosus*

Fungal species	Stand 1			Stand 2		
	No. of fungal isolates	biotic effect		No. of fungal isolates	biotic effect	
		individual	joint		individual	joint
Gliocladium fimbriatum	—	—	—	5	+7	+35
Hormodendrum cladosporioides	—	—	—	18	—5	—90
Hormodendrum elatum	—	—	—	60	—5	—300
Hormodendrum microsporioides	6	—4	—24	30	—5	—150
Hormodendrum olivaceum	276	—5	—1380	9	—6	—54
Mortierella isabellina	—	—	—	6	—4	—24
Mortierella nana	—	—	—	104	—4	—416
Mucor fragilis	—	—	—	4	+3	+12
Oidiodendron cerealis	7	—6	—42	—	—	—
Oidiodendron griseum	—	—	—	8	—4	—32
Penicillium chermesinum	7	—2	—14	—	—	—
Penicillium cyaneum	—	—	—	7	—5	—35
Penicillium decumbens	7	—2	—14	44	—4	—176
Penicillium fellutanum	25	—5	—125	—	—	—
Penicillium restrictum	—	—	—	12	+2	+24
Penicillium spinulosum	51	+1	+51	102	+3	+306
Penicillium velutinum	7	+2	+14	—	—	—
Penicillium vinaceum	6	—5	—30	—	—	—
Sporotrichum pulviniforme	6	—6	—36	—	—	—
Stysanus medius	—	—	—	16	—5	—80
Trichoderma album	6	+7	+42	—	—	—
Trichoderma glaucum	6	+7	+42	—	—	—
Trichoderma koningi	16	+7	+112	—	—	—
Trichoderma lignorum	8	+7	+56	22	+7	+154
Verticillium capitatum	20	+2	+40	—	—	—
Total	454		—1308	447		—826

Explanation: The number of fungal isolates in stand 1 is 454 which represents 82.1% of the total number of isolates. The summary biotic effect is —1308. The total number of fungal isolates in stand 2 was 447 which represent 91.2% of the total number of isolates. The summary biotic effect is —826.

Table 7

The effect of fungal isolates from the *Pinus sylvestris* rhizosphere in the studied stands on the growth of the fungus *Fomes annosus*

Fungal species	Stand 1			Stand 2		
	No. of fungal isolates	biotic effect		No. of fungal isolates	biotic effect	
		individual	joint		individual	joint
Absidia glauca	—	—	—	14	+5	+70
Aspergillus versicolor	17	—5	—85	23	—6	—138
Beauveria brongiartii	11	—5	—55	—	—	—
Cephalosporium charticola	6	—3	—18	—	—	—
Fusidium terricola	24	—5	—120	—	—	—
Hormodendrum elatum	8	—4	—32	—	—	—
Hormodendrum microsporioides	99	—4	—396	23	—5	—115
Hormodendrum olivaceum	15	—5	—75	11	—5	—55
Lacellina sp. 1	—	—	—	12	—5	—60
Monocillium humicola var. *humicola*	6	—6	—36	—	—	—
Mortierella isabellina	—	—	—	15	—5	—75
Not sporulating SRJ263	14	—6	—84	—	—	—
Oidiodendron cerealis	32	—5	—160	—	—	—
Penicillium chermesinum	—	—	—	121	—2	—242
Penicillium decumbens	61	—5	—305	101	—3	—303
Penicillium jenseni	33	—6	—198	—	—	—
Penicillium lanosum	6	+2	+12	—	—	—
Penicillium miczynskii	7	—5	—35	—	—	—
Penicillium piscarium	—	—	—	15	—6	—90
Penicillium spinulosum	28	—6	—168	188	—2	—376
Penicillium stoloniferum	—	—	—	39	—3	—117
Penicillium tardum	—	—	—	16	—4	—64
Scopulariopsis sp. 2	—	—	—	17	—1	—17
Trichoderma koningi	—	—	—	18	+6	+108
Trichoderma lignorum	—	—	—	31	+8	+248
Total	367		—1755	644		—1226

Explanation: The number of fungal isolates in stand 1 is 367 which represents 76.9% of the total number of isolates. The summary biotic effect is —1755. The total number of fungal isolates in stand 2 was 644 which represents 83.9% of the total numbers of isolates. The summary biotic effect is —1226.

Table 8

The effect of fungal isolates from the *Pinus sylvestris* roots in the studied stands on the growth of the fungus *Fomes annosus*

Fungal isolates	Stand 1			Stand 2		
	No. of fungal isolates	biotic effect		No. of fungal isolates	biotic effect	
		individual	joint		individual	joint
Absidia butleri	—	—	—	3	+4	+12
Absidia glauca	14	+5	+70	—	—	—
Absidia orchidis	—	—	—	44	+5	+220
Absidia spinosa	23	—6	—138	—	—	—
Fusidium terricola	4	—5	—20	—	—	—
Mortierella humilis	—	—	—	14	+4	+56
Mortierella isabellina	10	—5	—50	14	—5	—70
Mortierella vinacea	5	—3	—15	27	—4	—108
Mycelium radicis atrovirens	178	—5	—890	112	—5	—560
Penicillium adametzi	—	—	—	26	—5	—130
Penicillium decumbens	32	—5	—160	7	—6	—42
Penicillium fellutanum	—	—	—	7	—5	—35
Penicillium jenseni	44	—4	—176	7	—2	—14
Penicillium chermesinum	—	—	—	16	—6	—96
Penicillium lanosum	—	—	—	11	+5	+55
Penicillium restrictum	11	—5	—55	—	—	—
Penicillium spinulosum	38	0	0	155	—1	—155
Penicillium stoloniferum	6	+2	+12	—	—	—
Penicillium terlikowskii	3	—5	—15	—	—	—
Trichoderma glaucum	39	+7	+273	—	—	—
Trichoderma koningi	19	+7	+133	49	+8	+392
Trichoderma lignorum	63	+7	+441	55	+7	+385
Total	489		—590	547		—90

Explanation: The number of fungal isolates in stand 1 is 489 which represents 96.1% of the total number of isolates. The summary biotic effect is —590. The total number of fungal isolates in stand 2 was 547 which represents 98.0% of the total number of isolates. The summary biotic effect is —90.

DISCUSSION

In order to obtain a full picture of the effect of fungal communities of the forest soil environment in the studied stands on the fungus *F. annosus*, studies were conducted using Mańka's [15] method of the biotic series which enables an evaluation of the effect of these communities as a whole on this pathogen. The result of this investigation permits the conclusion that the fungal community in the soil of stand 2 is more resistant to the development of the fungus *F. annosus* than the soil community in stand 1. This is in agreement with the true situation that is observable in these stands, since in stand 1 the destructive activity of *F. annosus* is silviculturaly evident while in stand 2 it is not. In the present studies exceptionally strong action against *F. annosus* has been demonstrated by the fungal community isolated from the litter, the mycorrhizae and the rhizosphere, while the effect of fungal communities isolated from the soil and the roots was less evident. The strong antibiotic effect against *F. annosus* of some fungi living in the forest litter has been reported also by Björkman [1].

The protective value against *F. annosus* of various genera of mycorrhizae as well as of the same mycorrhizal genus in various conditions, is different since it depends on the function of the fungi acting as components of the mycorrhizae, which in turn depends on the influences of the given soil environment.

In the study the role of forest soil fungal communities and of mycorrhizae as protective factors for roots against attacks by the fungus *F. annosus* has been demonstrated. From the phytopathological point of view one would have to try and affect the qualitative and quantitative composition of soil fungal communities, including those associated with the tree through mycorrhizae, as to obtain a maximal increase in the resistance of the environment to the root rot fungus as well as to other diseases of the forest tree root systems.

CONCLUSIONS

1. The presented type of investigation may prove useful in the future combating of forest tree root diseases by providing one more criterium in dividing the forests according to the degree of endangerment to a given pathogen, such as *F. annosus*, and in evaluating the consequences of any silvicultural practice in the forest aimed at improving the biological resistance of the soil environment against the development in it of that or other pathogen. As is evident from the studies conducted this resistance

against root rot is expressed among other factors by a qualitative and a quantitative composition and therefore by the function of the fungal communities associated with the rhizosphere and the mycorrhizae.

2. The phytopathological function of various genera of mycorrhizae depends on their specific composition and on the function of the component fungi.

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ZAGADNIENIE HUBY KORZENI *FOMES ANNOSUS* (FR.) CKE. NA TLE ZBIOROWISK GRZYBÓW LEŚNEGO ŚRODOWISKA GLEBOWEGO

Streszczenie

Do badań wybrano dwa około 50-letnie drzewostany sosnowe, z których drzewostan 1 był w znacznym stopniu narażony na działanie *Fomes annosus,* drzewostan 2 zaś występował na obszarze wolnym od widocznego zagrożenia przez tego patogena. W wymienionych drzewostanach izolowano grzyby z gleby, ścioły, ryzosfery, korzeni sosny zwyczajnej i mikoryz. Zastosowane metody izolowania grzybów pozwoliły na uchwycenie właściwych proporcji zarówno ilościowych, jak i jakościowych badanych grup grzybów leśnego środowiska glebowego, co z kolei umożliwiło zbadanie tych grup jako wystarczająco kompletnych zbiorowisk i ich wpływu na wzrost grzyba *F. annosus.*

Z przeprowadzonych badań wynika, że zbiorowiska grzybów z drzewostanu 1 w znacznie większym stopniu sprzyjały rozwojowi grzyba *F. annosus* niż zbiorowiska grzybów z drzewostanu 2, co jest zgodne z wyżej przytoczoną charakterystyką nasilenia zagrożenia tych drzewostanów przez hubę korzeni (pierwszy wyraźnie zagrożony, drugi co najwyżej słabo).

Typ badań reprezentowany przez przedstawioną pracę może być wykorzystany do biologicznego zwalczania chorób korzeni drzew leśnych, przez dostarczenie jeszcze jednego kryterium dla rejonizacji lasów z punktu widzenia stopnia ich zagrożenia przez określonego patogena i dla oceny zabiegów gospodarczych świadomie dokonywanych w lesie z punktu widzenia kształtowania biologicznej odporności środowiska glebowego na rozwój i aktywność w nim określonego patogena. We wchodzących tu w rachubę badaniach ta odporność w stosunku do huby korzeni wyrażała się między innymi ilościowym i jakościowym składem, a tym samym i funkcją w stosunku do *F. annosus* zbiorowisk grzybów związanych głównie z ryzosferą i mikoryzami.

Стефан Ковальски

ПРОБЛЕМА КОРНЕВОГО ТРУТОВИКА *FOMES ANNOSUS* (FR.) CKE НА ФОНЕ СООБЩЕСТВ ГРИБОВ ЛЕСНОЙ ПОЧВЕННОЙ СРЕДЫ

Резюме

Для исследования были выбраны два сосновых древостоя в возрасте около 50 лет, в которых древостой 1 был подвергнут в более сильной степени действию гриба *Fomes annosus,* а древостой 2 произрастал на площади свободной от этого патогона. В вышеуказанных древостоях изолировали грибы из почвы, подстилки, корнеобитаемого слоя почвы, корней сосны обыкновенной и микориз. Примененные методы изолирования грибов позволили установить соот-

ветствующие как количественные так и качественные пропорции для групп грибов лесной почвенной среды, что в свою очередь сделало возможным изучение этих групп как достаточно полных сообществ и их влияния на рост гриба *Fomes annosus*.

Проведенные исследования показали, что сообщества грибов из древостоя 1 в значительно высшей степени благоприятсововали росту гриба *F. annosus*, чем сообщества грибов из древостоя 2, что соответствует вышеприведенной характеристике интенсивности угрозы для этих древостоев со стороны корневого трутовика (первый древостой под заметной угрозой, второй — под слабой угрозой или без угрозы).

Тип исследований представленный в настоящем труде может использовыватсья в биологической борьбе с болезнями корневых систем лесных деревьев, поскольку в нем дается лишний критерий для районирования лесов с точки зрения угрозы для них со стороны определенного патогена, а также для оценки хозяйственных мероприятий проводимых заведомо в лесу с целью обеспечения биологической устойчивости лесной почвенной среды к развитию и деятельности в ней данного патогена. В соответствующих исследованиях эта устойчивость к корневому трутовику выражалась м.пр. количественным и качественным составом, а тем самым и функцией по отношению к *F. annosus* сообществ грибов связанных преимущественно с корнеобитаемым слоем почвы и с микоризами.

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