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Fungi occurring in forests injured by air pollutants in the Upper Silesia and Cracow Industrial Regions of Poland

VI. Higher fungi colonizing the roots of trees in converted forest stands*

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Abstract

The most important fungi found in roots of diseased, and almost or recently dead trees are described. The plots studied were situated in 6-15 year old stands of tree species more resistant to industrial air pollutants than the Scots pine which they replaced. The studies were carried out in 6 variants in forests strongly and moderately injured or not affected by industrial emissions.

INTRODUCTION

Forest stands in industrial regions were found to be gradually dying out. Pathogenic fungi infecting the roots of trees weakened by atmospheric pollutants take part in this process. Systematic studies by Grzywacz and Ważny (1973) indicated, that *Armillariella mellea* (Vahl ex. Fr.) P. Karst. was the main treat to Scots pine where SO_2 was being emitted by newly established industries. For the entire country these authors reported a high increase in occurrence of *A. mellea* and a lower one of *Heterobasidion annosum* (Fr.) Bref. in the period 1963 to 1970 in Scots pine stands in industrial regions, as compared with their occurrence on other areas free from air pollution.

To decrease the pollution damage, particularly in Scots pine stands, a stand conversion program was initiated in Poland around 1962, especially in the Upper Silesia Industrial District. The pine stands are

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being substituted by tree species regarded traditionally as more resistant to pollution. Areas cleared of injured and gradually dying older pine were replanted with various deciduous and coniferous species. Since 1971 these plantations have been studied to check the correctness of the methods of stand regeneration and to find the best methods of forest management in individual zones exposed to industrial pollution. An important part of these studies is identification of the pathogenic fungi affecting regeneration. Detailed investigations of the fungi colonizing the trees have been undertaken. The present work presents the results of studies on fungi usually pathogenic in roots of diseased, dying and recently dead trees. Investigations on fungi colonizing the above-ground portions of trees were published earlier (Domański, S. Kowalski and T. Kowalski 1977).

MATERIALS AND METHODS

Twenty plots were selected in the following forest districts: Alwernia (Al), Gołonóg (Go), Herby (He), Ostrowy (Os), Panewniki (Pa) and Swierklaniec (Sw). They were situated in 6—15 year old plantations grown in the fresh coniferous forest, on cryptopodsolic soils developed on coarse sands, with a loam horizon at a depth of 100—120 cm and a water table below 200 cm. The ground layer consisted mainly of grasses and sometimes *Sarothamnus scoparius*, and in plantations under the canopy of older trees, *Calluna vulgaris* and *Vaccinium myrtillus*. Initial spacing was 2×2 m or 1×2 m both under the 100 year old Scots pine or in the open after clearcutting of the old stands which consisted usually of Scots pine with some *Betula verrucosa*, *Fagus silvatica* and *Quercus robur* and which were injured by pollution to various degrees. Four zones of the impact of emissions on forests were distinguished, in accordance with the regulations obligatory in Poland: zones of stands strongly (III), moderately (II) and sligthly (I) injured by air pollutants, and a zone free from air pollution (O).

The studies were carried out in 1973—1976 in six different variants depending on the degree of pollution injury, whether the areas were open or under canopy, the method of site preparation, the presence or absence of pine stumps, and whether fertilizers were applied before planting (Table 1). The total area of the study plots in each variant was 0,5 ha with three plots per variant except for two variants with two or four plots. Five control plots were in areas free of air pollution, three very close to the Upper Silesia Industrial District, with a total area of 0,5 ha. Two 0,5 ha plots studied in 1967 and 1976 in Ruciane Forest District (Ru) in northern Poland and Łagów Lubuski Forest District (Ła) in western Poland were also used as controls. There were large openings in five of these young stands with diseased, dying or recently

Table 1

Description of research variants

Variant	Zone of stands injured by air pollutants	Location of study plots	Stumps in study plots	Soil preparation for planting	NPK, Ca applied (+) before planting	Number of dying or dead trees	Soil* pH values (upper row) and organic matter % —(lower row) at depths: up to 25 cm.	70 cm.
1	III	open area: Sw-97d, Sw-125i**	pine stumps present	furrow ploughing		70	4.8 12.5	4.8 0.0
2	III	open area: Sw-931, Sw-100h Sw-151a	extracted	complete deep ploughing	+	91	6.3 2.7	4.9 1.9
3	II	open area: Go-78s, Pa-45d Pa-60	pine stumps present	furrow ploughing		172	4.8 5.9	4.8 0.0
4	II	open area: Al-136c, Pa-46c Pa-46h, Pa-47f	extracted	complete deep ploughing	+	283	5.5 1.1	4.7 0.9
5	II	underplanting: Pa-34i, Pa-38h Pa-62f	pine stumps present	furrow ploughing		158	4.8 10.2	4.7 0.0
6	0	open area: close to Upper Silesia- He-157n Os-53f, Os-57b	oak and pine stumps present	,,		297	4.3 12.1	5.0 0.0
		Łagów Lubuski Ła-211h	beech and pine stumps present	,,		60		
		Ruciane Ru-1890	oak and pine stumps present	,,		71		

* Mean data from tests obtained from the Forest Soil Laboratory in Katowice
** Coded plot designations are for forest district names and sections

dead trees with symptoms of root infection particularly around the old oak or beech stumps. The plots in Ruciane and Łagów Lubuski were studied once, in August. On the remaining 18 plots the observations were carried out in autumn of each year on 50 trees numbered and selected for observation, representing the three to five most numerous species, and in addition on all diseased and nearly or recently dead trees present in the area. Disease symptoms were described in the field and the cause identified directly when a fruitbody or unmistakable fungus organ was present on the roots or root collar. This was particularly the case with conifers killed by *A. mellea* which showed typical white mycelium under the bark and root collar and outflowing resin, characteristic for this disease only. Other fungi could be recognized only by fruitbodies at the root collar, and *H. annosum* also by cream coloured pustules at the base of thicker roots at depths of up to 25 cm. Since such cases were rare, however, especially in polluted plots identification was mainly possible on malt agar cultures of affected roots. Ten isolations were usually made from each tree exceptionally 2-3 times as many. Altogether 4074 trees were examined on the plots under strong and medium pollution of these trees 774 were diseased, dying or recently dead. In reference to the latter the percentage of trees with infected roots was calculated for the individual variants in both zones. In forests without pollution 994 trees were examined of which 428 were diseased or dying. In reference to the latter the percentage of tress with affected roots was calculated for the three types of areas under study.

RESULTS

The results of studies are presented in Tables 2-4. It follows from them that the fewest trees with infected roots occurred in the strongly polluted zone (15.8%), nearly four times less than in the moderately polluted zone (61.6%) and about six times less than in the pollution free areas tested (97.0%). *H. annosum* proved to be most frequently isolated from the infected roots in both polluted zones where it was found to occur in 26.2% of the diseased trees. This fungus was responsible for the infection of almost all deciduous and coniferous species in the study plots, most often *Quercus borealis* (6.6%), *Betula verrucosa* (5.9%), *Alnus incana* (4.3%) and *Pinus silvestris* (3.2%), and next came *Pinus nigra* (2.8%) and *Larix decidua* (2.2%), and sporadically (0.1-0.3%) *Acer platanoides, Fagus silvatica, Acer pseudoplatanus, Quercus robur* and *Sorbus aucuparia,* and also *Calluna vulgaris* and *Vaccinium myrtillus* (Table 2). The severity of infection in both zones depended mainly on site preparation before planting, especially on the presence or absence of old stumps (Table 3). This difference was most noticeable in the strongly polluted zone (variants 1-2) in which the incidence of *H. anno-*

Table 2

Occurrence of root-colonizing fungi in the different variants

Fungi	Intensity of occurrence in forest trees and shrubs, % Variants							
	1	2	3	4	5	close to Upper Silesia	6 Łagów Lubuski	Ruciane
Armillariella mellea			H 0.3; L 0.5 A 0.1; D 0.1; N 0.2	A 0.5; H 0.1	Q 0.1	H 2.6 K 4.0 M 47.5 D 0.2	H 0.2 H 0.7 M 11.6	H 0.2 H 0.7 M 12.6
Chondrostereum purpureum	D 2.9 H 1.4	A 0.1; H 0.1	A 3.4; B 0.3; C 0.1 D 2.1; H 0.7; L 2.0	A 0.3; D 0.9 P 0.3	A 0.5; E 0.2 F 0.3; M 3.1	D 0.2 G 0.2	M 0.9	M 3.3
Heterobasision annosum	L 0.8		M 0.1; P 1.0; Q 0.1 S 0.1		P 5.3; V 0.1	M 4.5		
Hypholoma fasciculare		A 0.3	A 0.2; H 0.2	B 0.1; D 0.2 H 0.1; P 0.1	F 0.3; H 0.1 M 0.3; P 0.3	M 0.2		
Nectaria radicicola	D 0.3	A 0.3; D 0.1 H 0.5	A 0.1; B 0.1; L 0.2	A 0.3; B 0.1 D 0.3; H 2.4 L 1.8; P 1.8	P 0.3	H 0.2		
Peniophora cinerea		A 0.1; D 0.1	A 0.2; D 0.1; H 0.1	A 0.4; B 0.1 P 0.1				
Pestalozia hartigii				P 0.5				
Pezicula cinnamomea		A 0.2; D 0.5	A 0.3; D 0.2; P 0.3	A 0.1; D 0.1 F 0.1; Q 0.1	A 0.1; F 0.6	D 0.2		
Pezicula livida		H 0.3	H 0.6	L 0.7	H 0.1	H 0.9 M 0.9		
Polyporus ciliatus		D 0.1	A 0.2		A 0.3			
Resinicium bicolor	L 0.1	H 0.3; L 0.1	A 0.4; D 0.3; H 0.2 P 0.3	A 0.1; D 0.3 H 0.3; L 0.1 P 0.3	A 0.3; M 0.8	M 0.2	M 0.2	
Rhizina inflata			M 0.3					
Schizophyllum commune			A 0.2	D 0.1	A 0.1			
Sterum hirsutum			A 0.1	A 0.1		D 0.2		
Stereum sanguinolentum	H 0.5	H 0.1		H 0.1	M 0.1	M 0.2		
Trametes hirsuta			A 0.1					
Verticillium albo-atrum				L 0.1				
Miscellaneous fungi	D 2.2 H 0.8 L 0.2	A 0.7; D 1.4 H 1.1; P 0.2	A 1.3; B 0.2; H 1.0 L 1.0; U 0.2	A 1.2; B 0.8 D 0.5; H 1.3 P 7.0	A 1.2; H 0.2 M 2.7; P 1.1	H 1.4 M 3.1	M 0.5	
No isolate	L 0.1	B 1.1; H 1.0 P 3.1; R 0.2	A 0.2; H 0.5; L 1.5 N 0.4; T 1.2	A 2.7; C 5.1 F 0.4; H 0.2 K 0.2; L 0.4 P 0.5; Q 0.1	A 0.5; F 0.6 M 1.0; P 0.8 Q 0.8	G 0.2 H 0.2 K 0.5 M 1.2		M 0.9
Total	9.3	12.0	23.3	33.2	22.2	68.8	14.4	16.8

The tree and shrub species are indicated by capital letters: A=*Alnus incana*; B=*Acer platanoides*; C=*Acer pseudoplatanus*; D=*Betula verrucosa*; E=*Calluna vulgaris*; F=*Fagus silvatica*; G=*Juniperus communis*; H=*Larix decidua*; K=*Picea excelsa*, L=*Pinus nigra*; M=*Pinus silvestris*; N=*Populus tremula*; P=*Quercus borealis*; Q=*Quercus robur*; R=*Salix* sp;. S=*Sorbus aucuparia*; T=*Tilia cordata*; U=*Ulmus scabra*; V=*Vaccinium myrtillus*

sum in the plots was about 25 times higher where stumps were left. In the zone of medium pollution it occurred about 13 times more often on diseased trees in plots with old stumps. The effect of stumps could be best observed in the plot Pa-38h (variant 5) where 12—15 year old *Q. borealis* trees were affected and began to die progressively in several groups in the centre of which either pine stumps or dead pines with *H. annosum* fruitbodies could be found. The fruitbodies of this fungus or their primordia in the form of small cream coloured pustules were rather scarce, occurring on no more than 1/3 of the infected trees in each zone, whether polluted or not (Table 4). On the pollution free plots the incidence of *H. annosum* was 9 times less than in both the polluted ones.

As concerns *A. mellea* the situation proved to be quite different. It was totally absent in strongly polluted study plots (variants 1-2) while on moderately polluted ones, in the open area (variants 3-4), it was discovered only in the roots of very few diseased trees of *A. incana* (0.5%), *P. nigra* (0.5%) and *L. decidua* (0.4%), and in plantations established in this zone under the canopy of old Scots pines (variant 5) it was found in only one dead *Q. robur* tree. Neither was it found on old dying or dead pines in stands in which the study plots Pa-34i, Pa-38h and Pa-62f were situated. Even the trees showing symptoms of infection with *Hypholoma fasciculare* (Huds. ex Fr.) Kummer and *Resinicium bicolor* (Alb. et Schw. ex Fr.) Parm. were about 1.5-2.5 times more numerous than those with symptoms of *A. mellea* activity in both zones. On the other hand, in study plots uninjured by pollution *A. mellea* was almost 30 times as active as in those with medium pollution and about 9 times as frequent as *H. annosum*.

Table 3

Occurrence of root-colonizing pathogenic fungi in study plots in different zones of forests injured by air pollution

Variants	Zone of stands injured by air pollutants	Stumps	Intensity of injury of trees, %			
			Armillariella mellea	*Heterobasidion annosum*	*Hypholoma fasciculare*	*Resinicium bicolor*
1	III	present	0.0	5.1	0.0	0.1
2	III	extracted	0.0	0.2	0.3	0.7
3	II	present	0.8	9.9	0.4	1.2
4	II	extracted	0.6	1.5	0.5	1.1
5	II	present	0.1	9.5	1.0	1.1
6	0	present	26.7	3.0	0.1	0.1

Of other isolated fungi assigned to "miscellaneous fungi" (Table 2) *Mycelium radicis atrovirens* Melin was most abundant (15.1%), being isolated from the roots sometimes alone, sometimes in association with

Nectria radicicola Gerlach et Nilsson [stat. conid.: *Cylindrocarpon destructans* (Zins.) Scholten] (in 8.1% of cases) or with *H. annosum* (in 1.8% of cases). Among rather numerous unidentified basidiomycetes (5.8%) there were some exhibiting strong antagonism towards *Penicillium* and even *Trichoderma*. *Trichoderma* species (4.0%) and especially *T. viride* Pers. ex Fr., *Penicillium* species (1.8%), *Phialophora* species (1.5%) and *Paecilomyces elegans* (Corda) Mason et Hughes (1.1%) were also fairly numerous, being mostly isolated from wood of roots badly injured by grubs in study plot Al-136c (variant 4) where there were no stumps or traces of pathogenic activity of *A. mellea* or *H. annosum*.

Table 4

Effect of various methods of detection of *Heterobasidion annosum* in dying or dead trees on the evaluation of disease severity in the variants examined

Variants	Percentage of infected trees		
	with fruitbodies in root collar	with pustules at the base of the lateral roots	total in respect to identification by isolation method
1	0.4	1.4	5.1
2	0.0	0.1	0.2
3	1.3	1.6	9.9
4	0.0	0.1	1.5
5	4.3	1.7	9.5
6	1.9	—*	—*

* Not tested

No fungi were isolated from the roots of 22.6% of dead trees growing in the study plots injured by pollution. The majority of such trees died back from the top downards but death had not yet reached the roots to make possible their infection by fungi colonizing the aboveground portions. This phenomenon was most frequently observed in *A. pseudoplatanus*, *Q. borealis*, *A. incana*, *L. decidua* and sometimes *F. silvatica* and *A. platanoides*. It probably accounts for the presence in the dead roots of a number of these tree species of *Chondrostereum purpureum* (Pers. ex Fr.) Pouzar, *Peniophora cinerea* (Fr.) Cooke, *Pezicula cinnamomea* (DC.) Sacc., *P. livida* (Berk. et Br.) Rehm, *Polyporus ciliatus* Fr. ex. Fr., *Schizophyllum commune* Fr., *Stereum hirsutum* (Willd. ex Fr.) S. F. Gray, *S. sanguinolentum* (Alb. et Schw. ex Fr.) Fr., *Trametes hirsuta* (Wulf. ex Fr.) Pilát known so far to infect dying or dead aboveground parts.

Table 5

Percent infection of trees by pathogenic root fungi presented as the function of height in variants examined

Variants	Height of trees infected as compared with maximum tree height in study plots	*Alnus incana*	*Betula verrucosa*	*Fagus silvatica*	*Larix decidua*	*Pinus nigra*	*Pinus silvestris*	*Quercus borealis*
1, 2	2/3—3/3		41.4		0.0	71.4		
	1/3—2/3		51.7		87.5	28.6		
	< 1/3		6.9		12.5	0.0		
3, 4	2/3—3/3	31.8	42.1		22.2	52.2		30.8
	1/3—2/3	47.7	36.8		44.5	39.2		46.2
	< 1/3	20.5	21.1		33.3	8.6		23.0
5	2/3—3/3	11.8		22.1			37.5	20.7
	1/3—2/3	82.4		55.6			62.5	55.2
	< 1/3	5.8		22.3			0.0	24.1
6	2/3—3/3						22.5	
close to Upper	1/3—2/3						63.7	
Silesia	< 1/3						13.8	
Łagów Lubuski	2/3—3/3						16.7	
	1/3—2/3						66.1	
	< 1/3						17.2	
Ruciane	2/3—3/3						35.2	
	1/3—2/3						60.6	
	< 1/3						4.2	

The process of dying of young trees caused by pathogenic root fungi both in the polluted and unpolluted study plots depended to a small degree on the species of tree involved and on its condition (Table 5). Infection and subsequent disease affected both the poorly developed or the tallest trees. Occasionally trees died rather unexpetedly, even those which a year before had were in good condition or not unfrequently displayed maximum height and growth in diameter.

DISCUSSION

In the light of traditional opinions on the incidence of root-attacking fungi in forests affected by industrial pollution, the results of the present studies as well as similar studies in the same region in young pure birch and pine stands (Domański, S. Kowalski and T. Kowalski 1976) are surprising. It was *H. annosum* and not *A. Mellea* that turned out to be the most important pathogens in young stands originating from the conversion of old Scots pine stands which for over 100 years have been none too strongly, lately more and more severely affected by industrial pollution. On the other hand, *A. mellea* was responsible for the highest mortality in the zone uninjured by air pollution, where, however, *H. annosum* showed reduced activity. A similar result was obtained in studies carried out at the same time in the forest districts Brynica, Swierklaniec and Żyglinek (Domański, S. Kowalski and T. Kowalski 1976) which quite recently have been affected by pollution. The investigations showed that *A. mellea* and *H. annosum* were found there, on 25-45% and 1.5-5%, respectively, of dead trees in 35-95 year old pine stands which only recently became exposed to intense pollution from a new industrial source. Similar comment may refer to the results obtained in Poland by Grzywacz and Ważny (1973) on the severity of disease caused by both these fungi. Judging by the distribution of the study plots, at least half of the Scots pine stands investigated by these authors came also, only recently, influenced by more or less strong atmospheric pollution. A similar ratio of incidence for both fungi was also obtained during studies at Ludwikowo in Wielkopolski National Park on the cause of death of 100 year old Scots pines uninjured by air pollutants (Domański 1953). The ratio of dead or dying trees with symptoms of *A. mellea* or *H. annosum* was 4 : 1. Detailed analysis of the root systems of healthy and dying older pines at Ludwikowo and pines in young stands in the study plots Ła-211h and Ru-189o (variant 6) showed that rhizomorphs of *A mellea* produce local points of infection, often quite numerous, especially on roots of older otherwise healthy trees. On study plots Ła-211h and Ru-189o, most probably owing to the greater susceptibility of young trees, decreasing with age, the fungus became more pathogenic after such infection and caused quick death of the young trees often independently of the degree of development of the latter. In the older Scots pine stands at Ludwikowo, however, *A. mellea* did not develop beyond the local points of infection on roots of healthy pines and did not cause disease as long as the trees were not weakened by a complex of additional damage factors. These usually consisted of intense regeneration feeding of *Tomicus piniperda* and *T. minor* in the crowns or stem canker caused by *Cronartium flaccidum* (Alb. et Schw.) Winter with necrosis of the tap and sinker roots at depths of 0.5-1.5 m. caused by *Onnia triqueter* (Alb. et Schw. ex Fr.) P. Karst. Next to a new source of powerful air pollutants, on the other hand, weakening of trees by air pollution is the factor initiating the pathogenic activity of *A. mellea* from local points of infection in the root systems in pine stands.

The present studies seem to indicate that the conditions in the forests uninjured by industrial emissions favour in the first place the saprophytic existence of *A. mellea* during which it is known to colonize the sources of nutrient substances, mostly stumps, especially deciduous ones, from which it may strongly infect young trees and cause their death. On the other hand, forest sites which have been under a bearable influence of industrial emissions for a very long time must now represent, at least in the study area, unfavourable conditions for the development of *A. mellea*, but do not hinder and even seem to intensify the activity of *H. annosum*.

Disease caused by *A. mellea* and *H. annosum* was always most severe in those study plots where stumps were not uprooted after previous clear cutting. It is not a new phenomenon (Greig and Burdekin, 1970; Heather, 1976; Rishbeth, 1951), although according to Yde-Andersen (1970) extraction of stumps does not always prevent the attack by *H. annosum* on various deciduous and coniferous species particularly when fragments of the infected roots were left in the soil.

The infection of roots of a small number of the young trees by *H. annosum*, especially in the plots where stumps were removed, may have been caused directly by basidiospores or conidiospores in the soil (Braun and Lulev, 1969, 1970). Alexander, Skelly and Morris (1975) suggest that the infection of roots of Loblolly pine (*Pinus taeda*) in loamy-sandy soils at depths up to 95 cm may be directly caused by *H. annosum* spores travelling down through noncapillary pores, and that such infection may be as dangerous as infection via root contacts. A similar suggestion could be made from studies in Poland in 100 year old Scots pine stands on loamy sand, where *H. annosum* infection was found at the tips of sinkers at depths of 0.5-1 m (Domański, 1953), and in deep sandy soils at the tip of the tap root at depths of 1-1.5 m (Domański and Dzięciołowski, 1955). The possibility of such infection may also apply to the plots under investigations, where young trees growing on sandy soils which may favour the downard movement of *H. annosum* spores (Alexander, Skelly and Morris, 1975) had roots often infected by *H. annosum* at depths up to 0.5 m and where *H. annosum* tended to produce abundant conidiospores at the root collars of dead trees (Domański, S. Kowalski and T. Kowalski, 1976). This infection may also depend on the quality of root exudates (Ladeschnikova, 1969; Schwaier and Blum, 1971). Their composition is probably favourable to the development of *H. annosum* in the rhizosphere.

Detection of fungi by isolation methods as compared with their recognition by fruitbodies, especially those of *H. annosum* on infected trees contributed significantly to a better evaluation of the role of pathogenic root fungi in the study plots. Table 4 shows how wide differences may occur in both methods with respect to *H. annosum*.

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Grzyby występujące w drzewostanach objętych szkodliwym oddziaływaniem emisji przemysłowych w Górnośląskim i Krakowskim Okręgu Przemysłowym

VI. Grzyby wyższe zasiedlające korzenie drzew w przebudowanych drzewostanach

Streszczenie

Badaniami objęto grzyby zasiedlające korzenie w 6—15-letnich mieszanych uprawach i młodnikach złożonych z gatunków drzew liściastych i iglastych odporniejszych na przemysłowe zanieczyszczenia powietrza niż drzewostany sosnowe rosnące w obu okręgach przemysłowych. Badania prowadzono w latach **1973—1976** na **18** stałych powierzchniach doświadczalnych założonych przez Instytut Badawczy Leśnictwa na siedlisku boru świeżego w strefie lasów silnie i średnio uszkodzonych przez emisje oraz, dla celów kontrolnych, na 5 powierzchniach wolnych od zanieczyszczeń. Podstawową metodą wykrywania grzybów zasiedlających korzenie było izolowanie grzybni z chorych lub martwych korzeni na pożywkę agarowo-maltozową. Na powierzchniach uszkodzonych przez emisje stwierdzono, że stosunkowo najwięcej drzew z korzeniami zakażonymi przez grzyby występowało w strefie średnio zanieczyszczonej i że głównym patogenem zakażającym korzenie prawie wszystkich gatunków drzew zarówno liściastych, jak i iglastych, był grzyb *Heterobasidion annosum* (Fr.) Bref., podczas gdy *Armillariella mellea* (Vahl ex Fr.) P. Karst. zakaziła tylko znikomą liczbę drzew. Natomiast na powierzchniach doświadczalnych zbadanych w strefie wolnej od zanieczyszczeń powietrza *A. mellea* była głównym grzybem patogenicznym zasiedlającym korzenie drzew przeważnie iglastych, podczas gdy *H. annosum* zakaził je 8—9 razy mniej licznie. Obecność pniaków pozostawionych na powierzchniach doświadczalnych miała największy wpływ sprzyjający występowaniu obu tych grzybów we wszystkich trzech badanych strefach lasów, przy czym silnemu występowaniu grzyba *A. mellea* w strefie lasów wolnych od zanieczyszczeń powietrza sprzyjała przede wszystkim obecność pniaków liściastych. Badania zdają się wskazywać na to, że *A. mellea* powoduje najintensywniejszą chorobę korzeni pierwszego pokolenia drzewostanów sosnowych osłabionych szkodliwym oddziaływaniem zanieczyszczeń powietrza z nowo wybudowanych zakładów przemysłowych. Natomiast warunki na siedliskach leśnych objętych od kilkudziesięciu lat stopniowo zwiększającym się przemysłowym zanieczyszczeniem powietrza zdają się sprzyjać patogenicznej działalności *H. annosum*, zwłaszcza w uprawach i młodnikach założonych na powierzchniach, z których usunięto stare drzewostany sosnowe uszkodzone przez emisje przemysłowe.