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Mushroom yields in 10-year-old coppice after spraying with MCPA

MARKKU KIRSI & PERTTI OINONEN

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The mushroom yield in a coppice in Ilomantsi, eastern Finland, was studied during the first three years following aerial MCPA ester spraying. In all three years the yields obtained from the coppice were greater than the yields from the adjacent mixed coniferous forest. MCPA treatment had no acute poisonous effect on the mycoflora but indirectly it caused pronounced changes in the total mushroom yields.

Markku Kirsi & Pertti Oinonen, University of Joensuu, Department of Biology, P.O. Box 111, SF - 80101 Joensuu 10, Finland

1. Introduction

Chemical brush control by plane has long been a routine practice in Finnish forestry. Earlier, preparations containing 2,4-D or 2,4,5-T, or mixtures of the two, were used almost exclusively. The public discussion on their possible ecologial drawbacks may have been responsible for the introduction of new arboricides, such as MCPA esters and glyphosate, in chemical coppice treatment in the latter half of the 1970s. No scientific reports exist on the influence of any of these herbicides on the mycoflora and the mushroom yield in coppice areas. In fact, until the last few years research on the subject of mushroom yields in forest sites has been very limited. Recent Finnish investigations have been directed towards elucidating the effect of fertilization on the mushroom yield on peatlands (Veijalainen 1974, Salo 1979) and in heath forests (Ohenoja & Takkunen 1974, Ohenoja 1978).

This paper reports on mushrooms and mushroom yields in a coppice in Ilomantsi commune in eastern Finland during the first three years following aerial MCPA iso-octyl ester spraying in 1976. The study is a part of a larger project of the Department of Chemistry and Biology, University of Joensuu, which deals with the ecological consequences of aerial arboricide treatment in a developing forest ecosystem (Tahvanainen 1980). The project was supported by grants from the Academy of Finland.

2. Materials and methods

A. Study area

The investigation was carried out during 1977—1979 in Ilomantsi, in the village of Lemivaara (62°50'N, 30°56'E) in eastern Finland.

The original *Vaccinium* type (VT) forest of the experimental site had been clear-cut in 1968. Shallow patches, about 2500 per hectare, were dug in 1969 and the area was sowed with pine *(Pinus sylvestris)* seeds in the same year. By the spraying year, 1976, the study area was covered by a dense bush layer of pine, about 2.0—2.5 m in height, and birch *(Betula pubescens* and *B. pendula)* and aspen *(Populus tremula)*, about 2.5 m in height, with some rowan *(Sorbus aucuparia)*, willows (*Salix* spp.), juniper *(Juniperus communis)* and small spruce *(Picea abies)*. The main dwarf shrubs were *Calluna vulgaris* and *Vaccinium vitis-idaea*, with some *Empetrum nigrum*. Herbs were abundant, the dominant species being, *Deschampsia flexuosa, Epilobium angustifolium, Deschampsia cespitosa* and *Calamagrostis epigejos*. There were a few mosses (mainly *Polytrichum commune* and *Pleurozium schreberi*) and very sparse lichen vegetation. The ground of the study area is flat. The soil is a typical podsol with an A-horizon of about 5 cm and B-horizon of about 10—15 cm.

The experimental site of 200 × 450 m was divided into three 200 × 150 m sectors, each sector was further divided into three 200 × 50 m strips (Fig. 1). The central strip of each sector was sprayed with arboricide, one strip was left as a control and on the third strip mechanical coppice treatment was carried out, to produce a mixed pine-birch stand, within a 60 m belt at the NE end of the strip.

The brush spraying treatment was carried out on August 10, 1976 by plane. The commercial preparation used (Brush Killer, Kemira Oy) contained the iso-octyl ester of 4-chloro-2-methyl phenoxyacetic acid (MCPA) at a concentration of 500 g/l. The rate of application was 5 kg of the preparation in 45 l of water per hectare.

B. Effect of MCPA treatment on vegetation

The MCPA iso-octyl ester preparation affected the trees most strongly. About 80—100 % of the deciduous bushes were dead in the following spring and after-sprouting was minimal. Most of the surviving birches and aspens were situated at the margins of the treated strips. The pines were damaged, too. In spring 1977 only one pine in two had a living leader and some of the smallest pines were completely dead. The pine injuries were partly due to pine-twisting rust *(Melampsora pinitorqua),* which had a mass occurrence in 1976. On the untreated strips, about 20 % of the pines hade dead leaders, apparently due to the rust. In the field layer the most severely injured species were *Calluna vulgaris* and *Vaccinium vitis-idaea;* about 50 % of their shoots died in consequence of the treatment. *Calluna vulgaris* recovered rapidly, however. By summer 1979 it had almost reached its original coverage and biomass in the experimental area (Lehikoinen 1980). *Vaccinium vitis-idaea* recovered much more slowly. The MCPA treatment had a minor effect on the other field layer species and no changes at all were observed in the ground layer.

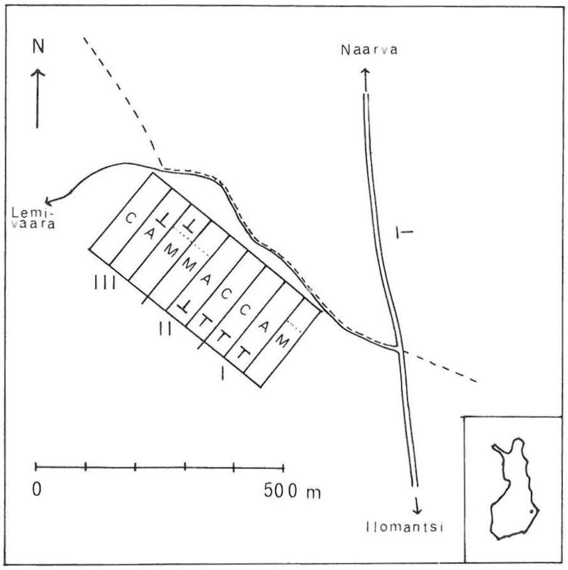

Fig. 1. The study area at Lemivaara in Ilomantsi, eastern Finland. The area has been divided into three sectors (I, II, III), each sector has a central MCPA-treated strip (A), a control strip (C), and mechanically coppice-treated strip (M). The sample plots are shown by bars.

C. Sample plots and sampling methods

Eight sample plots of 50 m^2 (2 × 25 m) were set up in 1977 in sectors I and II; four plots on the MCPA-treated strips and and four on the control strips (Fig. 1). In 1978 four further plots were set up on sector III, to give a total experimental area of 600 m^2. Each strip had two experimental plots perpendicular to each other. This guaranteed that the minor features of the sites were included in the sample plots — among other things the bottoms of the ditches were represented in the longitudinal plots.

All the mushroom fruit bodies were collected from each plot at 10—20 day intervals during the snow-free period (from the end of May to late September — early November) in 1977—1979. The fruit bodies were sorted by species, counted and weighed at Joensuu University within one or two days of sampling. The dry weights were recorded after drying at 80°C for 24 hours in 1977 and at 60°C for about 48 hours in 1978—1979. The species were identified by the authors on fresh material. Some of the dried specimens were determind by Miss Heli Heikkilä, Lic. Phil. (Kuopio Museum). Some of the fungi were identified only to the genus and the determinations may be slightly unreliable in certain cases. Specimens of the uncertain groups are preserved at the University of Joensuu.

3. Mushroom species

The mushroom species found on the sample plots during the growing seasons 1977—1979 have been listed in Table 1. The MCPA treatment had no fundamental effect on the total numbers of the fungal species. In 1977 and 1979 the chemically treated areas had 3—4 species fewer than the control areas but in 1978 they had 5 species more. About half of the c. 120 taxa occurred almost equally abundantly in the arboricide-treated plots and the untreated plots. Of the species restricted to the treated or untreated sample plots, most were found in a single plot, so that their occurrence may clearly be explained by chance. Among the most frequent species (growing on at least two strips), only *Lactarius vietus* and *Leccinum scabrum* were limited to the control plots, and *Gyromitra infula* was the only species growing merely in the MCPA-treated plots. Species clearly occurring more abundantly on the arboricide-treated than on the untreated areas were *Lactarius helvus, Omphalina* spp. and *Inocybe*

Table 1. Dry weight (g/ha) of the fungi collected in 1977—1979 in a coppice in Ilomantsi after aerial MCPA spraying; A = arboricide-treated, C = control, M = mechanically coppice-treated.

	1977		1978			1979		
	A	C	A	C	M	A	C	M
Aleuria aurantia	1							
Gyromitra infula	93		55			50		
Peziza badia			5			74		
Peziza sp.			2	10				
Cudonia confusa			12	2		25		
C. circinans			1					
Calocera viscosa			7			7	1	
Dacrymyces sp.			4					
Thelephora terrestris	1918	1056	1760	620	5617	208		73
Merulius tremellosus	65							
Coltricia perennis	200	25	252	111		148	151	
Gloeophyllum sepiarium	150	47	19	12			48	
Hirschioporus abietinus				238				
Polyporus brumalis								328
P. ciliatus	1					59	5	
P. melanopus						15		
Tyromyces sp.			41					
Leccinum scabrum				427	6160		3053	3735
L. variicolor		252						
L. vulpinum			173					
Suillus bovinus		68	35	1152	23	807	126	
S. luteus				89		38	210	
S. variegatus	1045	1008	579	4832	775	240	1192	
Xerocomus subtomentosus						113		
Lactarius helvus	838		573	160		666	452	
L. mammosus	18					10		
L. torminosus							200	
L. vietus		342		505	69		1200	167
Russula aeruginea	58							
R. emetica							21	
R. fragilis						18		
R. puellaris				93				
R. xerampelina							47	
Russula spp.		171		17		147		
Paxillus involutus	685	182	675		3770	858		7560
P. atromentosus						48		
Hygrophoropsis aurantiaca	6	3					15	
Gomphidius roseus		111	39	95		217	246	
Chroogomphus rutilus		42	9	88		5	259	
Hygrophorus olivaceoalbus				15				
Hygrophorus sp.		16						
Amanita fulva		24					380	
A. lividopallescens				25				
A. muscaria				424				
A. porphyria		11				88	12	
A. vaginata							384	
Lentinellus omphalodes		8						
Lentinellus sp.							3	
Lentinus lepideus					200	99		
Panellus serotinus		187	79	567		223	586	
Cantharellula umbonata	351	208	297	183	13	386	282	96
Clitocybe clavipes	206	72						
C. gibba	19							
Clitocybe sp.	71	6	31	30		47	15	6
Mycena epipterygia	94	51	13	16	6	83	34	
M. galericulata			144					
M. galopus							1	
M. laevigata						4		
Mycena spp.	13	4	16	3	1	11	38	1
Hemimycena sp.	5							

Table 1 (contd.).

	1977		1978			1979		
	A	C	A	C	M	A	C	M
Marasmius androsaceus	+		2	1		19	1	1
Marasmius sp.	1		+					2
Omphalina ericetorum			3					
O. sphagnicola						8		
Omphalina spp.	9	1	9	1		15		2
Xeromphalina campanella		41	1	3				
X. caulinalis						5		
Cystoderma amianthinum	47	17	51	39	3	50	15	9
C. granulosum	17	22	5		33			
Laccaria laccata	367	85	116	13	588	163		357
Oudemansiella platyphylla	627		123			49	199	
Collybia acervata								488
C. asema			6		667	53		512
C. butyracea					425			372
C. cookei		8						
C. cirrhata	5	+	2	2	11	1		1
C. dryophila		6	5					
C. succinea			3			3		
Collybia sp.			33				1	
Armillariella mellea	367	164	111	935		78	1148	
Lyophyllum sp.	15		67	17	12			
Tephrocybe sp.						21		
Tricholoma album						7	7	
T. flavobrunneum						56		
Pluteus atricapillus						24		
Pluteus sp.	19						93	
Rhodophyllus sp.	25	60	15	33		5	6	16
Rhodocybe sp.		2						
Stropharia hornemannii	494	943	260	1174		1903	81	
Psilocybe rhombispora								1
Psilocybe sp.			1					
Kuehneromyces mutabilis		343		2450		6	290	
Naematoloma capnoides	759	211	1230	619	2536	906	590	1308
N. polytrichii	29	15	8	4				5
Psathyrella sp.	11		13		21	1		13
Pholiota lubrica								10
Pholiota sp.	5		53	10				
Dermocybe cinnamomeobadia		77						
D. cinnamomeolutea	47	14	76	372	78	383	1171	74
D. semisanguinea	43		22		146	231		121
Dermocybe sp.							3	
Cortinarius anomalus						16		476
C. gentilis		4						
Cortinarius spp.	48	46	34	886	1506	130	970	495
Galerina hypnorum coll.	32	25	11	16	8	49	34	3
G. marginata			24			5	5	
Galerina sp.	12	17	17	8	22	14	7	3
Gymnopilus penetrans		39				243	17	123
Gymnopilus sp	188	12	88	29	52	35		
Inocybe fastigiata						33		
Inocybe spp.	174	48	124	76		182	23	66
Hebeloma mesophaceum								50
Hebeloma sp.			3			5		2
Agaricales spp.	+	9	21		2	9	9	2
Lycoperdon foetidum						5		
L. perlatum			52	11		1		
Lycoperdon sp.	18	18		12				
In all g/ha	9205	6121	7410	16425	22711	9261	13778	16478

spp. Species more abundant on the untreated areas were *Russula* spp., *Chroogomphus rutilus* and *Cortinarius* spp.

Since *Lactarius vietus* and *Leccinum scabrum* occur together with birch, their absence from the arboricide-treated sites was to be expected. The reason why those three taxa were more numerous at the untreated sites is not clear. *Chroogomphus rutilus* is a mycorrhizal fungus of pine and should have occurred in both treated and untreated plots. The fruit bodies of *Cortinarius* and *Russula* were not always identified to species. These two genera include mycorrhizal species of both conifers and broad-leaved trees, and the species differ greatly in their ecological requirements. Thus, the reason for their greater abudance in the control plots is uncertain.

All the species gaining an advantage from the chemical brush treatment were those which prefer soils free of vegetation. The sparse and patchy or completely dead field layer vegetation in the treated plots explains the distribution of these species.

4. Effect on mushroom yield

A. Total mushroom yield

The total mushroom yields per hectare in the study area were 92.9 kg in 1977, 158.2 kg in 1978 and 140.5 kg in 1979. In the uncut mixed coniferous forest 500 m northeast of the experimental area (Fig. 1) the corresponding values, estimated in two experimental plots of 50 m^2, were 81.9 kg, 50.3 kg and 133.4 kg. The total yield per hectare in the study area was thus of the same order of magnitude as in the forest in two of the years, and in 1978 it was three times as great, apparently due to the poor yield of *Russulas* in the forest.

In the MCPA-treated plots the total mushroom yields per hectare in the three study years were 96.7 kg, 74.2 kg and 122.6 kg. In the plots not treated with arboricide, the corresponding figures were 83.9, 242.2 and 158.3 kg. In 1977 the abundance of mushrooms was distinctly greater in the sprayed than in the control plots. In 1978 the yields were much larger on unsprayed strips in all three sectors than on the MCPA-sprayed strips (Fig. 2). In 1979 also, the yields were larger on the unsprayed strips, but the differences between the strips were less distinct.

The annual fluctuation in the mushroom yields was greatest on the unsprayed strips. The new sampling plots on sector III included in the sampling program in 1978 had higher yields than the plots on sectors I and II, and their inclusion resulted in an apparent increase in the annual fluctuation. However, it can be seen in Fig. 2 that the mushroom yields obtained in the unsprayed strips in 1978 were two- or threefold those of 1977 on sectors I and II, as well.

B. Yield of commercial mushrooms

Eight species of commercial mushrooms occurred in the study area. (The commercial mushrooms in Finland consist of 30 species recommended in 1971 by the Committee on the Economic Utilization of Mushrooms as being easily identified edible mushrooms with good flavour and productivity.) Of these *Suillus bovinus, S. variegatus, Armillariella mellea, Kuehneromyces mutablis* and *Naematoloma capnoides* produced fruit bodies every year. In 1977 *Suillus bovinus* occurred only in the control plots; in 1978 it was very abundant in the control plots and occurred in small quantity in the sprayed plots, too, but in 1979 its abundance was significantly greater in the MCPA-treated than in the untreated plots. *S. variegatus* had the largest yield among the commercial mushrooms. In 1977 it was equally abundant on the treated and control plots, after which its yield was poorer on the sprayed areas than that on the control areas. The yield of *Armillariella mellea* had the same pattern, but no distinct trends

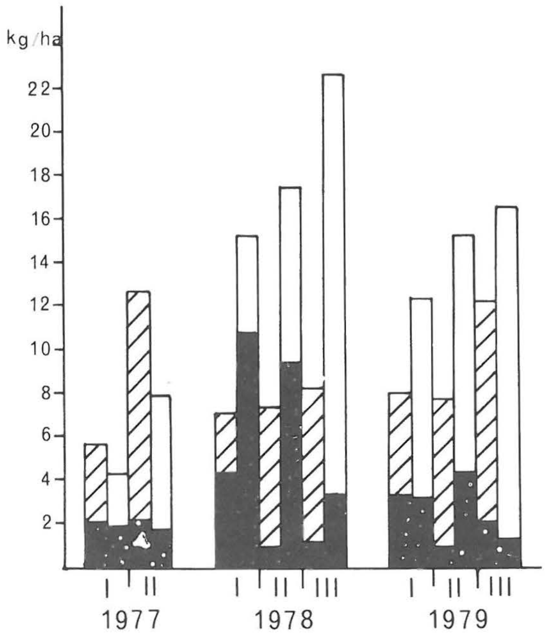

Fig. 2. Mushroom yields (dry wt, kg/ha) on the MCPA-treated and control strips in 1977—1979. I, II, III, = sector number; hatched = MCPA-treated strip; shaded = commercial mushrooms.

were observed in the yield of *Naematoloma capnoides*. *Kuehneromyces mutabilis* was too rare to allow any conclusions about the effect of MCPA treatment on this fungus. The same was true of the other commercial mushrooms found in the study area, viz. *Suillus luteus, Leccinum vulpinum* and *Lactarius torminosus*.

The annual and spatial fluctuation in the yield of the commercial mushrooms was fairly pronounced (Fig. 2). The proportion of commercial mushrooms was largest in 1978 on sector II, where they amounted to 70 % of the total yield. The smallest yields of commercial mushrooms (0.8—0.9 kg dry wt/ha) were obtained in 1978 and 1979 on the sprayed strips of sector II, and their proportion was lowest on the coppiced strip of sector III (7.9 %). The difference between the MCPA-sprayed and unsprayed areas was most pronounced in 1978, when the yield of the commercial mushrooms on the control strips was 1.6—8.7-fold the yield on the sprayed strips. In 1977 there were no differences and in 1979 the difference was notable only on sector II.

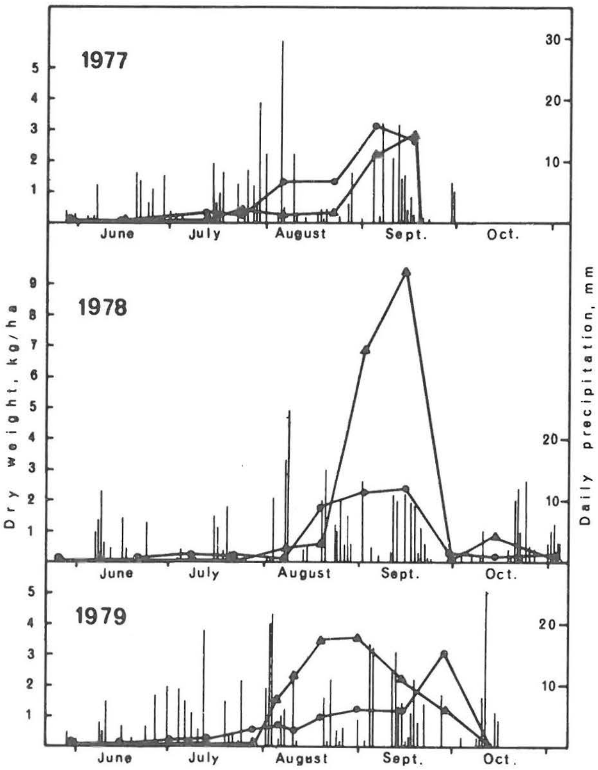

Fig. 3. Seasonal fluctuations in mushroom yields (dry wt, kg/ha) in 1977—1979 and mean daily precipitation (mm) at the meteorological station of Ilomantsi (18 km S of the study area); ●—● yield from MCPA-treated plots, ▲—▲ yield from control plots.

5. Seasonal pattern of mushroom yields

The weather conditions at the nearest meteorological station, at Ilomantsi village (62°41' N, 30°57' E), are shown in Table 2, and the seasonal pattern of the mushroom yields is illustrated in Fig. 3.

Table 2. Mean temperatures (°C) and precipitation (mm) in May-November at the meteorological station of Ilomantsi in 1977—1979.

Year	Month						
	V	VI	VII	VIII	IX	X	XI
	Mean temperature						
1977	8.4	13.5	15.6	13.1	4.3	0.8	—2.1
1978	8.6	12.8	15.0	11.8	7.0	0.9	—1.5
1979	10.2	14.0	15.2	14.4	7.7	0.7	—1.4
1930-1961	7.3	13.1	16.0	14.1	8.3	2.1	—2.7
	Precipitation						
1977	62	42	83	73	91	79	81
1978	2	45	34	112	80	63	75
1979	60	43	73	108	120	62	82
1930-1961	37	62	79	75	70	64	49

In 1977 and 1979 the amounts of mushrooms began to increase at the beginning of August. In 1978 the rather low precipitation during spring and midsummer delayed the beginning of the mushroom season but the plentiful rains in August and the first half of September caused peak yields in the second half of August and in September. The end of the mushroom season was mainly determined by the snow. In 1977 the first snow came on September 20 but it melted soon and the mean daily temperatures rose above 0°C for a couple of days, probably allowing the development of some new fruit bodies. As these were not collected, the total mushroom yield for 1977 may have been a little higher than reported here. In 1978 night frosts were common after September 24, resulting in an abrupt decrease in mushroom abundance. In spite of the frequent night frosts, the mushroom season continued at a low level (mainly *Thelephora terrestris, Naematoloma capnoides, Panellus serotinus* and small-sized saprophytic species) until it was terminated by the establishment of a permanent snow cover in mid-November. In 1979 the mean daily temperature remained below zero after October 22, but the mushroom season had been ended a week earlier by an ample fall of snow.

The differences in mushroom yields between the MCPA-treated and control plots were immaterial in the middle of the summer, when the total yields were low. In August 1977 the sprayed areas had significantly more fruit bodies than the unsprayed areas, 2745 g dry wt/ha *versus* 550 g/ha. The species mainly responsible were *Thelephora terrestris, Suillus variegatus, Oudemansiella platyphylla* and *Lactarius helvus*. The difference became smaller later on and had disappeared by the last collecting day, September 19. In 1978 the relations between the mushroom yields from the treated and control plots were the same as in 1977 up to mid-August. In September the yield in the control plots was exceptionally high but that of MCPA-treated plots kept at the same level as in the previous year. The mushrooms chiefly contributing to the superiority of the yields from the control areas were *Suillus variegatus, Leccinum scabrum, Kuehneromyces mutabilis, Thelephora terrestris, Stropharia hornemannii, Suillus bovinus* and *Armillariella mellea*. The species responsible for the small October peak in the control areas were *Thelephora terrestris, Panellus serotinus, Hirschioporus abietinus* and *Naematoloma capnoides*.

In 1979 the control areas were superior to the sprayed areas from the beginning of August up to mid-September, the species with the highest yields in the control plots being *Leccinum scabrum, Paxillus involutus, Lactarius vietus, Suillus variegatus* and *Armillariella mellea*. During the second half of September the sprayed areas were clearly more productive. The difference was almost exclusively due to the abundant occurrence of *Stropharia hornemannii* in one sprayed plot.

6. Discussion

The mushroom yields obtained from the coppice at Lemivaara (93—158 kg/ha) were greater than the yields from the adjacent mixed coniferous forest and quite comparable to the yields reported for pine forests on other parts of Finland. Rautavaara (1947) has estimated that in Finland the average mushroom yields in pine forests are 72—114 kg/ha and in mixed spruce forests 90—150 kg/ha. According to the estimates of Ohenoja (1978), in Muhos in 1973—1975 the mushroom yields ranged from a few kilograms to over 300 kg per hectare, being more often below than above 100 kg/ha. The mushroom yields on the brush area at Lemivaara correspond well with these figures. One reason why the coppice had greater yields than the adjacent forest is that its mycoflora was more varied. The number of tree species is higher in coppice than in closed forest, allowing the occurrence of many species of mycorrhizal fungi. The stumps and logging residue provide ample substrates for wood-rotting saprophytic fungi, and the network of ditches creates a variety of microhabitats in the otherwise uniform terrain.

The influence of the MCPA iso-octyl ester treatment on the species composition of the mushrooms was insignificant. Clear differences between the chemically treated and untreated areas were few, and some of them were probably due to the patchy distribution of the fruit bodies. Estimation of the effect of external factors on the frequency of the fungal species is complicated by the uneven distribution and the large annual fluctuation in the amounts of fruit bodies at the same site. But the results show clearly that the MCPA coppice treatment has no acute poisonous effect on the mycoflora. The total numbers of mushroom species were similar at the treated and untreated sites and the greater part of the most frequent species occurred in both the control and treated plots. This result is not particularly surprising. Applications of herbicides at normal field rates have not been reported to cause changes in the total numbers of soil microorganisms or in the gross microbial activity (Audus 1964, Bollen 1961). Despite the numerous reports of inhibition of fungal growth by synthetic auxins, including MCPA esters (Gruen 1959), there seems to be no reason to suppose that auxins are active growth regulators in fungi (Burnett 1976). MCPA seems to be less fungitoxic than some other herbicides (Wilkinson & Lucas 1969). Although growth was depressed, most of the saprophytic soil fungi tested by Wilkinson and Lucas were able to grow in media containing up to 1000 ppm MCPA. Sixteen days after the spraying in Ilomantsi the concentrations of MCPA residues were 239 ppm dry wt in birch twigs, 37 ppm in moss and 0.1—4 ppm in the soil (Eronen et al. 1979). In the following year (1977) the figures for birch twigs, moss and soil were 44—76 ppm, 0 ppm and 0—0.7 ppm, respectively. The residues in fungi were low: in a sample of *Suillus luteus* taken six weeks after the treatment the MCPA concentration was below 0.1 ppm (Eronen et. al. 1980).

These figures suggest that the toxic effect of MCPA treatment on the mycoflora cannot be significat. In contrast to the negligible effect of MCPA treatment on the occurrence of single species, its effect on the mushroom yields was pronounced. This was due to the numerous changes in the brush ecosystem caused by the arboricide treatment. Abrupt alterations in the plant cover will strongly affect the proportions of species in the tree and field layers and the amount and quality of the plant litter. Theoretically, these alterations may also influence the soil fauna, soil microbes, and concentrations of mineral nutrients, but such consequences of the MCPA treatment were evidently so slight that they were not clearly demonstrable (Tahvanainen 1980).

One probable explanation of the superior mushroom yield on the sprayed strips in the year following the MCPA treatment may be a temporary increase in dead plant material. In 1978 the amount of tree leaf litter decreased abruptly on the sprayed areas, though the litter originating from the field layer stayed constant (Kasila 1980). Together with the death of the host plants of mycorrhizal fungi, this decrease in tree leaf litter and the resultant reduction in the cycling rate of mineral nutrients may be among the factors responsible for the lowered mushroom yields on the sprayed areas in later years.

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References

Audus, L.J. (ed.) 1964: The physiology and biochemistry of herbicides. — 555 pp. London and New York.

Bollen, W.B. 1961: Interractions between pesticides and soil micro-organisms. — Ann. Rev. Microbiol. 15: 69—92.

Burnett, J.H. 1976: Fundamentals of mycology. — 673 pp. London.

Eronen, L., Julkunen, R. & Saarelainen, A. 1979: MCPA residues in developing forest ecosystem after aerial spraying. — Bull. Environm. Contam. Toxicol. 21: 791—798.

Eronen, L., Julkunen-Tiitto, R. & Saarelainen, R. 1980: MCPA-jäämät lentoruiskutuksen jälkeen puolukassa, sienissä, karikkeessa ja maaperässä. In: Tahvanainen, J. (ed.), Vesankotorjunta-alueiden ekologinen ja ekofysiologinen tutkimus. Loppuraportti. — Pp. 5—10. Joensuun korkeakoulu.

Gruen, H.E. 1959: Auxins and fungi. — Ann. Rev. Plant Physiol. 10: 405—440.

Kasila, H. 1980: Vesakontorjunnan vaikutuksista karike-tuotantoon ja karikkeen hajotukseen nuoressa VT-metsikössä. In: Tahvanainen, J. (ed.), Vesakontorjunta-alueiden ekologinen ja ekofysiologinen tutkimus. Loppuraportti. — Pp. 51—64. Joensuun korkeakoulu.

Lehikoinen, M. 1980: MCPA-ruiskutuksen vaikutuksista kenttä- ja pohjakerroksen kasvillisuuteen. In: Tahvanainen, J. (ed.), Vesakontorjunta-alueiden ekologinen ja ekofysiologinen tutkimus. Loppuraportti. — Pp. 37—50. Joensuun korkeakoulu.

Ohenoja, E. 1978: Mushrooms and mushroom yields in fertilized forests. — Ann. Bot. Fennici 15: 38—46.

Ohenoja, E. & Takkunen, N. 1974: Alustavia tietoja lannoituksen vaikutuksesta kangasmetsän sienisatoon. (Summary: Preliminary notes on the effect of fertilizers on the mushroom yield of heath forests in Muhos in 1973) — Pyhäkosken Tutkimusaseman Tiedonantoja 10: 1—25.

Rautavaara, T. 1947: Suomen sienisato. — 534 pp.Forssa.

Salo, K. 1979: Mushrooms and mushroom yield on transitional peatlands in central Finland. — Ann. Bot. Fennici 16: 181—192.

Tahvanainen, J. (ed.) 1980: Vesakontorjunta-alueiden ekologinen ja ekofysiologinen tutkimus. Loppuraportti. — 154 pp. Joensuun korkeakoulu.

Veijalainen, H. 1974: Metsäojitusalueiden sienisadosta. (Summary: Mushroom production on drained peatlands.) — Suo 26: 31—33.

Wilkinson, V. & Lucas, R.L. 1969: Effects of herbicides on the growth of soil fungi. — New Phytol. 68: 709—719.

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