

## **Mycorrhizal potential of two forest research plots with respect to reduction of the emissions from the Thermal Power Plant Šoštanj**

**Mikorizni potencial dveh gozdnih raziskovalnih ploskev po zmanjšanju emisij iz Termoelektrarne Šoštanj**

Samar AL SAYEGH PETKOVŠEK & \*Hojka KRAIGHER

ERICo Velenje, Koroška 58, 3320 Velenje, Slovenia;

E-mail: samar.petkovsek@erico.si

\*Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana; Slovenia;

E-mail: hojka.kraigher@gozdis.si

**Abstract.** The mycorrhizal potential of two differently polluted forest research plots was determined in the emission area of the Thermal Power Plant Šoštanj. Zavodnje is the polluted, while Mislinja is the less polluted plot. Mycorrhizal potential of the soils from the two sites was estimated in a pot experiment. Types of ectomycorrhizae were identified in the soil cores and on short roots of Norway spruce seedlings. The fresh weight of needles and stems, number of short roots and the percentage of mycorrhizal short roots on seedlings from Zavodnje were significantly lower in comparison with Mislinja. The results indicate that the mycorrhizal potential of the more polluted site is lower. Mycorrhizal potential is discussed with respect to the results from our earlier studies.

**Key words:** ectomycorrhizae, mycorrhizal potential, Norway spruce seedlings, forest research plots

**Izvleček.** Določili smo mikorizni potencial dveh različno onesnaženih gozdnih ploskev v imisijskem območju Termoelektrarne Šoštanj. Zavodnje predstavlja onesnaženo, Mislinja pa manj onesnaženo raziskovalno ploskev. Mikorizni potencial obeh območij smo določili z lončnim poskusom. Tipe ektomikorize smo identificirali v talnih vzorcih raziskovalnih ploskev in na kratkih koreninah semenk smreke. Sveže teže iglic in stebel semenk (nadzemni del), število kratkih korenin in število nemikoriznih kratkih korenin semenk, ki so rastle na substratu iz Zavodnj, je statistično značilno manjše v primerjavi Mislinjo. Rezultati kažejo, da je mikorizni potencial bolj onesnaženega območja nižji. Mikorizni potencial smo primerjali z rezultati naših prejšnjih raziskav.

**Ključne besede:** ektomikoriza, mikorizni potencial, semenke smreke, gozdna raziskovalna ploskev

## Introduction

Ectomycorrhiza is the site of exchange of nutrients between the plant and the fungus. Fungal hyphae exploit the soil for mobilisation and absorption of water and nutrients (BRUNNER 2001). They are integral, functional parts of plant roots, in which the fungi involved provide a direct link between the soil and the roots (LEYVAL & al. 1997). Furthermore the mycelia of ectomycorrhizal fungi act as temporal and spatial connections between different species of trees in the forest ecosystem (AMARANTHUS & PERRY 1994).

In the last decades damages of forest trees and ecosystems have been monitored in North America and Europe. These can be connected with the disturbances in the ectomycorrhizal symbiosis. The deposition of pollutants into the forest ecosystems leads to the acidification and/or eutrophication of the forest soil and can consequently affect the health and vitality of forest trees (BRUNNER 2001). The impact of pollution on forest soils can be estimated by determination of mycorrhizal potential of forest soil of differently polluted areas. Pollution can influence the below – ground diversity of ectomycorrhizal fungi since some types can better survive different stress factors than others (GIANINAZZI-PEARSON 1984, VODNIK & al. 1995, TAYLOR 1995).

In Slovenia the mycobioremediation method for determination of pollution stress has been used (KRAIGHER & al. 1996) and in spruce forest the reduction of biodiversity of types of ectomycorrhizae due to pollution was established (KRAIGHER 1999). On the other hand biodiversity indexes were high in all beech forest research plots, therefore the impacts of pollution on beech ectomycorrhizae was not stated (AL SAYEGH PETKOVŠEK & KRAIGHER 2000). In studies of oak decline KOVACS reported that the ectomycorrhizal diversity decreased slowly but significantly in two oak stands in the north-east of Austria and the presence of some morphotypes were highly correlated with the crown-status of the trees (KOVACS & al. 2000).

The objectives of the present study were to determine mycorrhizal potential of two differently polluted forest research plots and to identify the types of ectomycorrhizae on short roots of mature trees and seedlings according to the concept of mycorrhizal succession (DIGHTON & MASON 1985, LAST & al. 1987) and biodiversity studies (KRAIGHER 1999, KOVACS & al. 2000, FERRIS & al. 2000).

## Material And Methods

The mycorrhizal potential of forest soil is defined as the capability of propagules of naturally occurring fungi in forest soils to colonize roots of spruce seedlings. It is expressed as the percentage of mycorrhizal short roots of the total number of short roots in the sample (KROPAČEK & al. 1989). A modified method of a pot experiment for determination of the mycorrhizal potential was used (AL SAYEGH PETKOVŠEK 1997). Differently polluted research plots are situated in the emission area of the Thermal Power Plant Šoštanj (TPP) where the negative impact of pollution is well demonstrated in all parts of environment (SVETINA 1999, POKORNY 2000, KUGONIČ & STROPNIK 2001, RIBARIČ LASNIK & al. 2001, POKORNY & RIBARIČ LASNIK 2002). The two plots (850 m a.s.l., distric cambisol, *Luzulo-Fagetum*, predominant tree species *Picea abies*), were as similar regarding site characteristics as it was possible to select, but polluted differently by the emissions from the TPP, as indicated by the lichenological studies (BATIČ & KRALJ 1990) and by the total S% and Pb content in soil (Tab. 1, sampling done in August 2001). Soils from both plots were dug from the upper 20 cm, sieved (2 mm sieve) and used as planting substrates. At the same time types of ectomycorrhizae were identified in soil cores (275 ml volume, 0 – 18 cm deep) from both research plots. 5 seedlings (at 3 weeks of age) per pot and 5 pots per soil source were grown for six months in the germination cabinet, where the growth conditions were the same for all seedlings. After six months the seedlings were weighed, short roots were counted and the percentage of

mycorrhizal short roots and the types of ectomycorrhizae were determined. The determination of types of ectomycorrhizae followed the procedure from the "Colour Atlas of Ectomycorrhizae" (AGERER 1987-1999) and other primary sources of identification.

Data from the study in 1993 and 2002 were compared. The difference was in the reduction of the emissions from TPP: the reduction of the emissions from the Thermal Power Plant Šoštanj was from 86.147 t SO<sub>2</sub> in the year 1993 to 22.871 t in the year 2002. *Statistica for Windows 5.5* has been used for statistical analyses. The results represented in Graph 1 are the average values for seedlings from two different locations, the significance of the difference was evaluated by non-parametric statistical analyses (Man-Whitney U test).

Table 1: Sieved soil analysis data for two forest research plots (P93-polluted plot in 1993; P02-polluted plot in 2002; U93-unpolluted plot in 1993, U02-unpolluted plot in 2002)

	pH CaCl <sub>2</sub>	pH H <sub>2</sub> O	C%	N%	C/N	K Ekv	P Ekv	S%	Pb mg/kg	Cd mg/kg	Hg mg/kg	As mg/kg
P 93	3,76	4,3	6,5	0,30	22	0,14	Traces	0.07	-	-	-	-
P 02	3.44	4,0	16,8	0,59	29	0,10	Traces	0,09	115	0,57	0,26	6,15
U 93	3,36	3.8	17,0	0,82	21	0,50	Traces	0.06	-	-	-	-
U 02	3.99	4,6	7,47	0,34	21	0,10	Traces	0,06	53,4	0,26	0,29	6,15

## Results and Discussion

The percentage of mycorrhizal short roots of seedlings from Zavodnje was significantly lower ( $p < 0.05$ ) in comparison with Mislinja (Fig. 1), consequently it could be concluded that mycorrhizal potential of the more polluted area is lower. Also other growth parameters of the seedlings were different: the fresh weights of stems and needles were higher in Mislinja, while the number of nonmycorrhizal roots were lower in Mislinja in comparison to Zavodnje. The average fresh weight of roots did not differ significantly. This is comparable also to the results of the study done eight years ago (Fig. 2, data on 1993 calculated from AL SAYEGH PETKOVŠEK 1997).

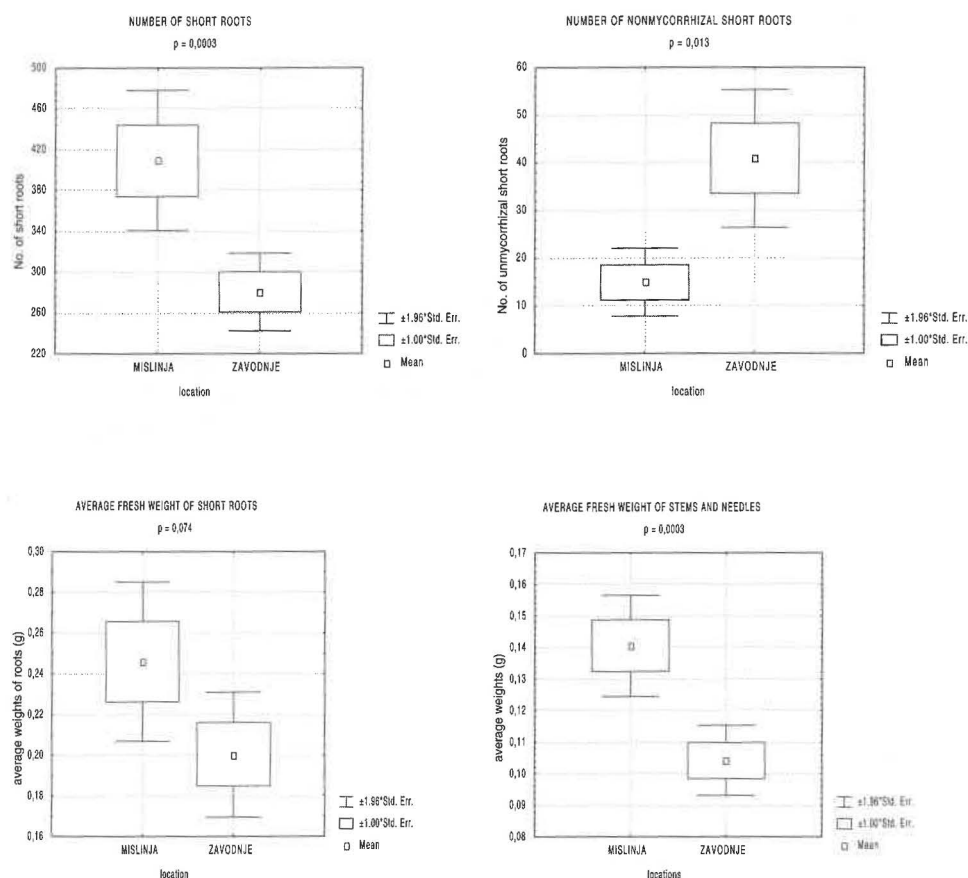


Figure 1: Comparison between different parameters of Norway spruce seedlings grown in soil substrates Mislinja and Zavodnje.

Our recent and previous study (AL SAYEGH PETKOVŠEK & al. 1995, AL SAYEGH PETKOVŠEK 1997, AL SAYEGH PETKOVŠEK & KRAIGHER 1998) on the same topic strongly indicate that pollution influences the mycorrhizal potential of forest soils. Negative impact is still present in spite of the reduction of the emissions. However the decrease in pollution seems to result in higher percentage of mycorrhizal short roots in current study as compared to former research. This increase in mycorrhization is characteristic for both plots.

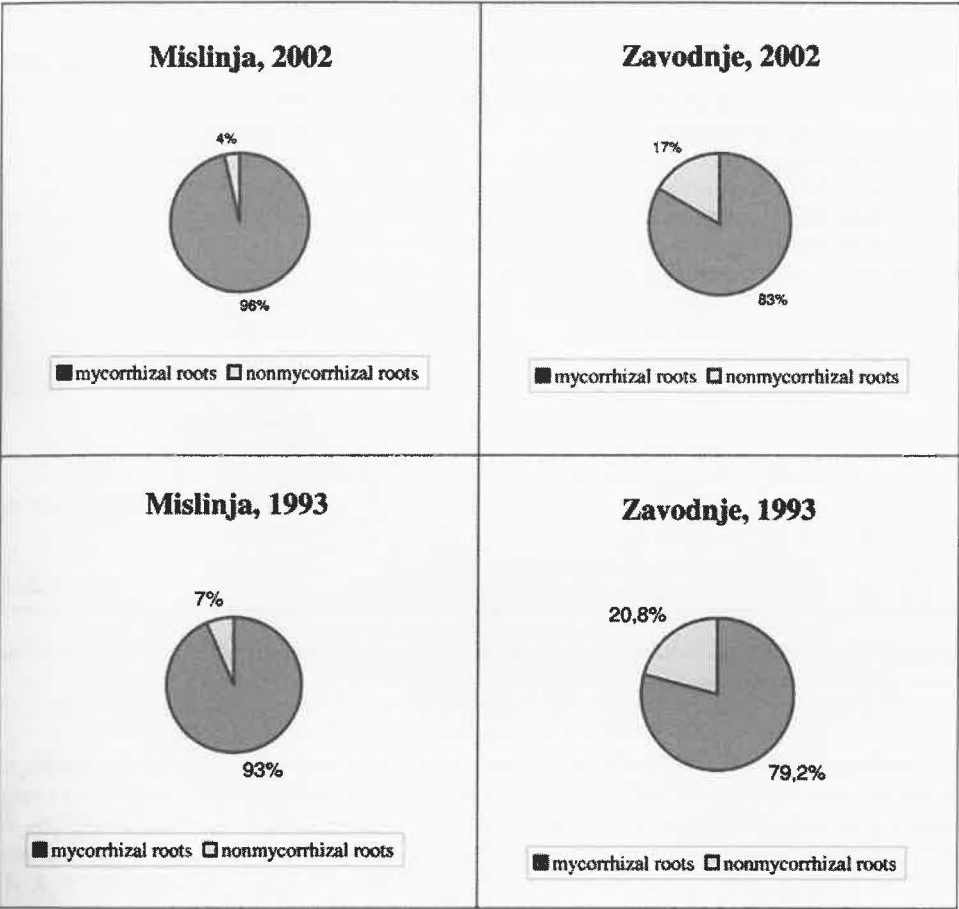


Figure 2: Mycorrhization of short roots of Norway spruce seedlings in pot experiments in the year 2002 and 1993.

Different types and different number of ectomycorrhizae were determined on short roots of mature trees in differently polluted forest research plots. 13 types of ectomycorrhizae in the soils from Mislinja and 8 types of ectomycorrhizae in the soils from Zavodnje (Tab.2) were identified. Three types of ectomycorrhizae were identical for both plots: *Cenococcum geophilum* Fr., *Lactarius pallidus* Pers. ex Fr. and *Suillus* sp. These types belong to the group of types of ectomycorrhizae named "late stage fungi" (LAST & al. 1987). Among the type described, *Scleroderma citrinum* Pers. has been regarded as un-sensitive to pollution (ARNOLDS 1991). Also in our study *S. citrinum* was frequent in the soil samples from the polluted area (Zavodnje).

Table 2: Types of ectomycorrhizae identified in the soil cores.

TYPES OF ECTOMYCORRHIZAE		FOREST RESEARCH PLOT
SLO 801 - SA1	<i>Xerocomus badius</i> (Fr.) Kühn.: Gilbert	Mislinja
SLO 802 - SA2	<i>Piceirhiza obscura</i>	Mislinja
SLO 803 - SA3	<i>Cenococcum geophilum</i> Fr.	Mislinja, Zavodnje
SLO 811 - SA11	<i>Tylospora fibrillosa</i> (Burt) Donk	Zavodnje
SLO 813 - SA13	<i>Russula acrifolia</i> Romagn.	Mislinja
SLO 836 - SA24	<i>Dermocybe</i> sp.	Mislinja
SLO 863 - SA63	<i>Thelephora terrestris</i> Pers.	Mislinja
SLO 875 - SA75	<i>Amphinema byssoides</i> (Pers.) J. Erikss.	Zavodnje
SLO 888 - SA70	<i>Xerocomus</i> sp.	Zavodnje
SLO 897 - SA97	<i>Russula</i> sp.	Mislinja
SLO 899 - SA99	<i>Tuber rufum</i> *	Mislinja
SLO 890 - SA52	<i>Lactarius pallidus</i> Pers. ex Fr.*	Mislinja, Zavodnje
SLO 901 - SA101	<i>Tuber borchii</i> Vitt.*	Mislinja
SLO 902 - SA102	<i>Boletus edulis</i> Bull.: Fr.*	Mislinja
SLO 903 - SA103	<i>Suillus</i> sp.	Mislinja, Zavodnje
SLO 904 - SA104	<i>Inocybe</i> sp.	Mislinja
SLO 906 - SA106	<i>Lactarius subdulcis</i> Bull.: Fr.*	Zavodnje
SLO 907 - SA107	<i>Scleroderma citrinum</i> Pers.*	Zavodnje

Legend: Types marked with \* are similar (not identical or described on a different plant sp.) to the types presented in the table.

Two types of ectomycorrhizae were determined on six months old Norway spruce seedlings: *Hebeloma mesophaeum* Qué. and *Cenococcum geophilum*. The first type is very common on young trees and could be considered as an "early stage fungus" (INGLEBY & al. 1990, DIGHTON & MASON 1985), while the *C. geophilum* has a world-wide distribution on a wide range of plants (SMITH & READ 1997) and it has been found on seedlings and mature trees (INGLEBY & al. 1990). Since black types of ectomycorrhizae named as *C. geophilum* were not well differentiated after anatomical characteristics in the past (therefore it was also considered as a "group species" as in AL SAYEGH PETKOVŠEK & KRAIGHER 1999) its different ecology might possibly been due to an involvement of several species with similar characteristics in different physiological and ecological references.

## Conclusions

- (i) Mycorrhizal potential as a bioassay for soil substrate pollution (with S and heavy metals) is an acceptable mycobioremediation method.
- (ii) The differences between the two sites were statistically significant, although the pollution effects are not highly destructive with respect to mycorrhizal soil inoculum potential.
- (iii) Eventhough the emissions from the TPP were reduced in the last decade, the revitalization of soil substrates is a slow process, therefore it might take several more decades before the mycorrhizal potential of the polluted and the unpolluted site reach the same level.

- (iv) Types of ectomycorrhizae present in the soils from the two sites represent all-stage as well as late-stage fungi, reflecting that soil substrates originate from old-growth forests and closed Norway spruce stands.
- (v) Types of ectomycorrhizae are of primary importance for the functioning of the forest ecosystem, however the simplified situation in the pot studies of mycorrhizal potential supports the primary importance of the % of mycorrhizal short roots while identification of types of ectomycorrhizae is of a secondary importance for application in bioindication methods.
- (vi) Due to the still noticeable impact of pollution on mycorrhizal potential of forest soils further analyses of mycorrhizal potential are recommended in order to continuously monitor the changes in ectomycorrhizal communities after the reductions of the emissions from the Thermal Power Plant Šoštanj.

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