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Diversity of Types of Ectomycorrhizae on Norway Spruce in Slovenia

By

Hojka KRAIGHER[1)]

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Summary

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Types of ectomycorrhizae on Norway spruce have been studied in different forest ecosystems in Slovenia. In approximately 100.000 root tips sampled 29 types have been identified or comprehensively described by anatomical and molecular characteristics, 4 could be identified to the genus level, while more than 20 types still await comprehensive characterisation. From these data diversity indexes (species diversity (d) and Shannon-Weaver index of diversity (H)) were calculated. The highest diversity was found in an autochthonous altimontane spruce stand on Pokljuka, lower in anthropogenic montane spruce stands in Mislinja and Zavodnje, while the lowest diversity was found in anthropogenic altimontane spruce stands, overgrown by grasses, on Pohorje. Forestry practice and its consequences, such as compact grass undercover, has been suggested to have a great impact on biodiversity of the mycorrhizal component in the forest soils. We propose a hypothesis that in natural pure spruce stands an extreme diversity in the mycorrhizosphere of the forest soils can counterpart the lower diversity among the higher plants.

Introduction

Forest ecosystems are functionally and structurally highly organised systems of biotic and abiotic components, linked into a sensitive dynamic equilibrium. The main spatial and temporal linkage between different constituents in a forest ecosystem, which can change due to anthropogenic derived stresses, represent the mycelia of mycorrhizal fungi (AMARANTHUS & PERRY 1994, SIMARD 1996). Functional compatibility of the symbionts in the mycorrhizae, their

[1)] Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana, Slovenia. Fax: +386 61 123 1343, e-mail: Hojka.Kraigher@gozdis.si

physiology and tolerance to stress factors is species specific (GIANINAZZI-PEARSON 1984). Therefore, knowledge on the abundance of ectomycorrhizal types is necessary in order to understand the functioning of a forest ecosystem.

With studies of types of ectomycorrhizae in Slovenian forests we try to contribute to studies of biodiversity in forest ecosystems, to the abundance and role of different types of ectomycorrhizae in Norway spruce forests and the impacts of pollution, forestry practices or other stresses on the diversity in forest soils.

Material and Methods

Types of ectomycorrhizae were studied in soil cores (274 ml, 0 - 18 cm deep), sampled in differently polluted forest research plots (in Zavodnje (polluted, 21 soil cores) and in Mislinja (unpolluted, 21 soil cores), 850m a.s.l., emission area of Thermal Power Plant in Šoštanj), in different developmental phases (autochthonous Norway spruce stand on Pokljuka, Triglav National Park, 1200m a.s.l., 13 soil cores in the old forest, 17 soil cores in the young growth, 3 soil cores in the clear cut area) and in differently treated Norway spruce stands (anthropogenic stands, covered by grasses, Pohorje, 1200m a.s.l., 20 soil cores). In mycorrhizal samples, all the roots were counted and types of ectomycorrhizae briefly characterised and counted (after AGERER 1987-1998, as described in KRAIGHER & al. 1995). Non-turgescent types were put in single category of old unidentifiable types. From these data (approximately 100.000 root tips; data taken from TROŠT & al. 1999, SIMONČIČ & al. 1998, KRAIGHER & al. 1996, ROBIČ & al. 1998) two diversity indexes were calculated (after ATLAS & BARTHA 1981), as follows: i) Species richness (d): $d = (S-1) / \log N$, where S = no. of species, N = no. of individuals; ii) Shannon-Weaver Index of Diversity (H): $H = C / N (N \log_{10} N - S^{S}_{i=1} n_i \log_{10} n_i)$, where C = 2,3, N = no. of individuals, n_i = no. of individuals in the i^{th} species, Sn_i = sum of calculations for all species present (S) in i^{th} species.

Results and Discussion

In approximately 100.000 root tips in soil cores from different forest ecosystems, which have been analysed in the last five years:

- only 1-2% were not mycorrhizal,
- 38-66% were old, non-turgescent, unidentifiable types,
- 29 types were identified to species level or comprehensively characterised,
- 4 types were identified to group or genus level,
- 20 types await to be comprehensively characterised.

Diversity indexes for types of ectomycorrhizae from three different forest research plots (Table 1) indicate the dynamics of an ecosystem, i.e. its possibility to react on the changing environment (ATLAS & BARTHA 1981). Species richness index (d) links the number of species and their importance in the total community. Shannon-Weaver index (H) presents also the relative abundance of each species, which can indicate whether there are any dominant populations in the sample. Both indexes are lower in populations from the stressed environments. From the physiological aspect, a reduction in the species can influence negatively the capability of populations of mycorrhizal fungi and of tree seedlings to form functional symbiosis. Therefore, the survival of natural regeneration of forest trees on sites with diminished species richness of mycorrhizal fungi can be reduced.

Table 1. Mycorrhization (%) and diversity indexes for types of ectomycorrhizae (ECM) on Norway spruce from three forest research plots in Slovenia (data from TROŠT & al. 1999 (a), SIMONČIČ & al. 1998 (b), KRAIGHER & al. 1996 (c), ROBIČ & al. 1998 (d), data on H index for vegetation from URBANČIČ & KUTNAR 1998).

Field plot	Pokljuka			Zavodnje	Mislinja		Pohorje	
Type of stand	Forest (a)	Young growth (a)	Clear cut (b)	Forest (c)	Forest (c)	Grass (d)	Cover (d)	Control (d)
No. root tips / l	6716	2572	1825	4844	6602	1764	4309	8235
No. of soil cores	13	17	3	21	21	5	8	6
ECM types (%)	40	39	29	40	53	60	62	61
Old types (%)	60	61	66	58	46	40	38	39
Nonmycorrhizal (%)	1	2	4	2	1	0	1	1
No. of types / core	10	10	6	9	11	6	11	10
Species richness (d)	4.69	2.56	1.88	3.79	4.18	0.72	2.52	2.25
H index (types)	2.23	1.52	1.48	2.27	2.21	0.65	1.64	1.52
H index (vegetation)	1.08	1.71	1.17	-	-	-	-	-

The highest diversity in the mycorrhizal component in forest soils on Pokljuka was observed in soil cores from the optimal developmental phase, lowest on the clear-cut and intermediate in a young growth forest (TROŠT & al. 1999). The limitations for natural regeneration of Norway spruce are classically compared to the irradiance regime. However, survival of shaded ectomycorrhizal trees has been proven to depend on the mycelial networks, whereby different types of ectomycorrhizae have a different role in nutrient acquisition and translocation (SIMARD 1996, LINDAHL & al. 1998). Since natural regeneration of Norway spruce on these plots is highly mosaic, mycorrhizal connections could counterpart the light-temperature-dependent regeneration.

The studies of ectomycorrhizae on two differently polluted forest research plots (KRAIGHER & al. 1996) showed a low H index, indicating the presence of a dominant population. Therefore, pollution can influence the distribution of mycorrhizal fungi, whereby several species can disappear while the others can profit from the new less competitive stage in the stressed forest ecosystem.

From mycorrhizal aspects of the regeneration of spruce in anthropogenic altimontane spruce stands, overgrown by grasses (ROBIČ & al. 1998), it could be concluded, that the species richness (d) was lowest of all plots so far, while H showed the presence of dominant populations of a few types. All silvicultural approaches to prevent grass growth had a big influence on species richness, which might influence the flow of nutrients in such forest stands.

On the other hand when the data on diversity indexes of types of ectomycorrhizae and the diversity index calculated for the vegetation cover (data from URBANČIČ & KUTNAR 1998) have been compared (Table 1) these last were lowest in the old growth autochthonous spruce stand and highest in the young regeneration centre from the same site. The diversity indexes of ectomycorrhizae from this site were three times higher, while those from the anthropogenic spruce cultures were of the similar range as for vegetation cover from a natural stand. This indicates that the bio-stability of autochthonous Norway spruce stands can be due to the high diversity of the biotic component in the forest soils.

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References

AGERER R. (Ed.) 1987-1998. Colour atlas of ectomycorrhizae, 1st-11th delivery. - Einhorn, Schwäbisch Gmünd.

AMARANTHUS M. P. & PERRY D. A. 1994. The functioning of ectomycorrhizal fungi in the field: linkages in space and time. - Plant and Soil 159: 133-140.

ATLAS R. & BARTHA R. 1981. Introduction to microbiology. - Addison-Wesley Publishing Company, Reading.

GIANINAZZI-PEARSON V. 1984. Host-fungus specificity, recognition and compatibility in mycorrhizae. - In: DENNIS E.S., HOHN B., HOHN TH., KING P., SCHELL I. & VERMA D.P.S. (Eds.), Genes involved in plant-microbe interactions, pp. 225-254. – Springer Verlag, Wien.

KRAIGHER H., AGERER R. & JAVORNIK B. 1995. Ectomycorrhizae of *Lactarius lignyotus* on Norway spruce, characterised by anatomical and molecular tools. - Mycorrhiza 5: 175-180.

— , BATIČ F. & AGERER R. 1996. Types of ectomycorrhizae and mycobioindication of forest site pollution. - Phyton (Horn, Austria) 36: 115 - 120.

LINDAHL B., STENLID J., OLSSON S. & FINLAY R. 1998. Interactions between mycelia of ectomycorrhizal and wood decomposing fungi. - In: AHONEN-JONNARTH U., DANELL E., FRANSSON P., KAREN O., LINDAHL B., RANGEL I. & FINLAY R. (Eds.), Second international conference on mycorrhiza (ICOM II), programme and abstracts, July 5-10, 1998, Uppsala, Sweden, p.109. – SLU Ultuna.

ROBIČ D., VILHAR U. & KRAIGHER H. 1998. Silvicultural aspects of grass competition in the rizosphere of an anthropogenic altimontance spruce culture. - In: DIACI J. (Ed.), Mountain forest, conference proceedings, the 19th forestry days, March 26-27, 1998, Logarska dolina, pp. 255-268. - BF Ljubljana.

SIMARD S. 1996. Interspecific carbon transfer in ectomycorrhizal tree species mixtures. - PhD Thesis, Oregon State University, USA, 210 pp.

SIMONČIČ P., SMOLEJ I., RUPEL M., URBANČIČ M., KALAN P. & KRAIGHER H. 1998. Nutrient cycling and diversity of ectomycorrhizae in the spruce forest on the Pokljuka plateau. – In: DIACI J. (Ed.), Mountain Forest, Conference proceedings, the 19th forestry days, March 26-27, 1998, Logarska dolina, pp. 207-221. – BF Ljujbljana.

TROŠT T., AGERER R., URBANČIČ M. & KRAIGHER H. 1999. Biodiversity of ectomycorrhizae in a Norway spruce stand on Pokljuka. - Phyton (Horn, Austria) 39 (4): 225-232.

URBANČIČ M. & KUTNAR L. 1998. Diversity of soil conditions and ground cover vegetation in forests on the moraines of Pokljuka plateau. - In: DIACI J. (Ed.), Mountain forest, conference proceedings, the 19th forestry days, Mach 26-27, Logarska dolina, pp. 242-254. - BF Ljubljana.