The role of mycorrhiza in reforestation

(A mikorrhiza szerepe az erdősítésekben)

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Abstract

Hungary is facing to perform intensive afforestation on 700 thousand – 1 million hectares during the next 40 years. New forests and wood plantations will be planted mostly on dry, poorly fertile soils nonprofitable for agricultural use to be found firstly on the Great Hungarian Plain. Applying artificially mycorrhized seedlings may considerably increase the effectivity of afforestation assuring of more intake of nutrients and water for the seedlings.

Keywords: Mycorrhiza, nutrient and water uptake, reforestation

INTRODUCTION

Hungary had always belong to the European forefront of quantitative afforestation. Therefore after the Second World War the forest area could be increased from 11 % by the present to 19 %. The extent of agricultural territories suitable for afforestation in the country is calculated to be between 700 thousand and 1 million hectares [1,2,3].

The agricultural territories possibly involved in afforestation belong partly to the very dry, sandy areas where the drougth is often raised by high lime content. The other part of land potentially usable for afforestation is the steeps of mountains and hills previously covered by woods. These areas have been cultivated for centuries but exhaustion and erosion degraded the soils, so their agricultural use is nonprofitable. The humus content of these soils is very low, usually below 1 %. In additon agricultural soils miss the normal microbiota of forest soils the trees are adapted to and contain higly different microbe communities disadvantageous for the development of planted seedlings.

It can be stated that the roots of tree seedlings planted into agricultural soils get into a hostile environment which a part of the plantlets cannot cope with. That is one reason why new plantations must be planted in average 1,6 – 1,7 times or even twice.

According to our results merely in Bács-Kiskun County there are more than 300 thousand hectares of unpritable agricultural land can be proceeded. In such case afforestation seems to be the most reasonable land use [4].

Rapid ecological changes of the last years (e.g. warming up, drying and sink of underground water level) warn us to look for new ways of afforestation succesful also in disadvantageous circumstances. Establishing artificial mycorrhizae on the roots of seedlings is such a new and in addition a natural method.

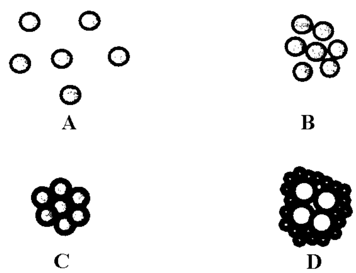
THE EFFECT OF MYCORRHIZAE ON THE NUTRIENT AND WATER UPTAKE OF FOREST TREES

Mycorrhiza, a symbiotic relationship between roots and fungi, is widespread all over the world. Different types of mycorrhizae, characteristic to plant communities having evolveld in different geographical and climatical zones, exist. In the decidous and needle woods under temperate climate trees typically form ectomycorrhizal connections mainly with basidiomycetes, less with some ascomycetes. There are of course some broadleaved species having endomycorrhiza connections (*Fraxinus sp., Acer sp., Prunus sp., Sorbus sp., etc.*)

The mycorrhiza fungi have a great influence on the growth, water and mineral uptake of the trees to be as host plants and they can increase their drought-tolerant. Moreover, fungal strains differ widely in this respect. Several mechanisms are involved: a direct effect on water uptake through various strategies of soil exploration by the mycelium, an indirect effect through the modification of water status regulation by the tree and changes in the water-use efficiency of photosynthetic carbon.

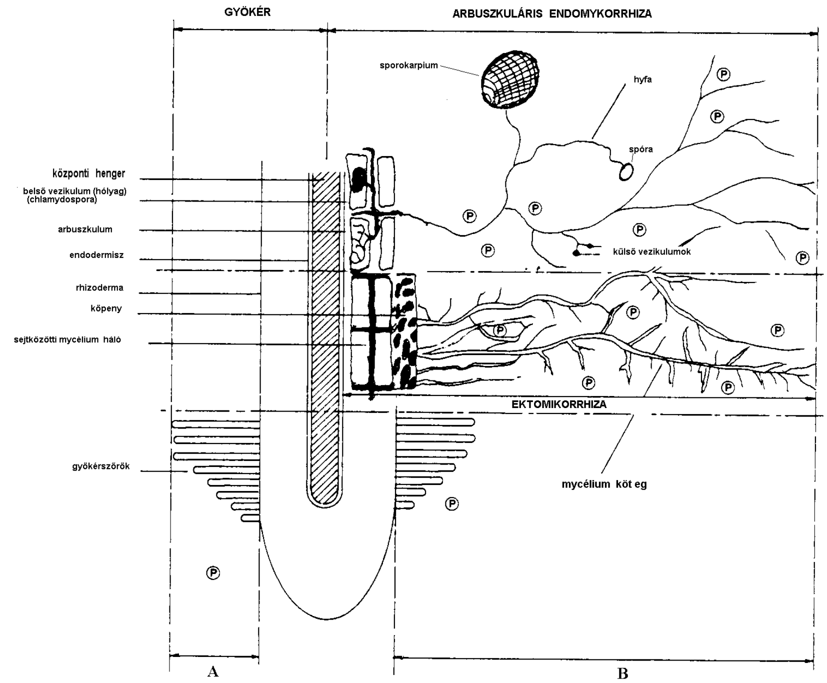
In ectomycorrhizae, a dense sheet of fungal mycelium, the so called *mantle*, is covering the root tips. Emanating hyphae, growing from the mantle into the soil, multiply the covered soil volume, and permit the increased water and mineral uptake. It happens the same way in the case of endomycorrhizae (Fig. 1-2.)

The advantage of mycorrhizae compared to non-mycorrhized plants is more distincly manifested in dry soils, poorly supplied with phosphorous and nitrogen. Mycorrhization increases growth (Table 1.) as well as P ans N content of plants (Table 2.)



A: myceliums consisting dispersed, individual hyphae
B: myceliums organised loose bundle
C: mycelium bundle containing closed connected hyphae
D: complex, water-conduit rhyzomorpha consisting thick, hollow hyphae inside and thin, cortical hyphae outside

Fig. 1. Organization of hyphae bundle [7]
(A hyfa kötegek szerveződése a víz és a tápanyag szállítás céljából)



A: the uptake-zone of roots (1 mm)
B: the uptake-zone of mycorrhiza (more than 10 cm)

Fig. 2. The extension of mineral and water uptake-zone surroundings of mycorrhiza [PLENCHETTE et al. 1982 cited in 10]
(A víz és a tápanyag felvételi zóna kibővítése a mikorrhizák segítségével)

Mycorrhiza help plants to survive dry periodes and adapt to limy [8, 9, 13]. Mycorrhizal seedlings can tolerate higher soil temperature and lower pH conditions. Mycorrhizae increase toleance of plants against inorganic and organic toxic substances, protecting them from heavy metal stress [5, 6, 14, 15]. This is extremely significant economically in afforestation and reafforestation of dry, poor and polluted areas.

Soil	Non-mycorrhized control	Natural mycorrhiza	Pisolithus tinctorius	Hebeloma cylindrosporum
1.	1,4 ± 0,2	3,5 ± 1,2	10,6 ± 1,6	13,5 ± 2,1
2.	0,6 ± 0,3		7,3 ± 2,6	8,9 ± 1,7
3a.	1,4 ± 0,7	3,5 ± 0,5	7,7 ± 0,7	6,9 ± 1,1
3b.	1,5 ± 0,3		4,6 ± 0,8	3,8 ± 0,4

The test was realised partly in controlled conditons. One part of the 3.5 months age seedlings were inoculated with artificialy produced mycelium, the other part of them were inoculated with naturaly mycorrhized root extract.
The soil samples were taken from the A level.
1. humous podzol; 2. eluviated adobed sand; 3a. slightly humous sand (humous content < 0,55 %); 3b. slightly humous sand (humous content = 0,08 %).

Table 1. The effect of ectomycorrhiza on overground growth of Pinus pinaster seedlings 10 months after planting out (fresh plant mass in g) **[MOUSSAIN et al. 1979 cited in 10**
(Az ektomikorrhiza hatása a Pinus pinaster magoncok föld feletti növekedésére, 10 hónappal a kiültetés után – a zöld növény tömege g-ban)

Content	Non-mycorrhized control	Natural mycorrhiza	Pisolithus tinctorius	Hebeloma cylindrosporum
Total P	0,09	0,17	0,21	0,32
Total N	1,79	2,19	2,10	2,77

Table 2. The effect of mycorrhization on the N and P content on overground parts of Pinus pinaster seedlings 10 months after planting out
(expressed in % of dry mass)
(A mikorrhiza hatása a Pinus pinaster magoncok N és P felvételére, 10 hónappal a kiültetés után – a szárazanyag tömeg %-ában kifejezve)
[MOUSSAIN et al. 1979 cited in 10]

During the planting seasons 2004. spring there were outplanting black locust (*Robinia pseudoacacia)*, white poplar (*Populus alba*) and ash (*Fraxinus excelsior*) one year old seedlings by the Forest Enterprise Kiskunság Co. in the region between Danube and Tisza (Table 3).

The soil types on which the reforestations were realised were sandy, the humus content less than 0,5 %, the lime content more than 10 %. This reforestation region is one of the most arid region of Hungary. The average precipitation is less than 550 mm.

There were applicated two different methodes of mycorrhiza treatment:

- seedlings were mycorrhized by the inokulation of the nursery soil;

- seedlings were mycorrhized by dipping in inokulum just before the outplanting in the forest.

After one vegetation period leaf samples were taken to examine their nutrition contants. The leaf analysis was made by the Central Laboratory (Kecskemét) of the Research Institute for Viticulture and Enology of the Ministry of Agriculture. The results of this analysis is summerised by the table 4. It can be seen that the nutrition content of the mycorrhized plants are heigher than the non-mycorrhized ones.

Locality Község Tag, részlet	**Mycorrhized area** Mikorrhizált terület (ha)	**Applicated mycorrhized seedlings (1000 pieces)** Felhasznált mikorrhizált csemete (edb)		
		Black locust **A**	**White poplar** **FNY**	**Other broadleaved** **E LOMB**
Forestry Firection Nord-Kiskunság (Észak-Kiskunsági Erdészet)				
Szalkszentmárton 10C	0,3			2,0
Solt 4SZ-5SZ	1,0		4,2	
Solt 16C	4,0		16,2	
Ágasegyháza 16J	0,5	2,1		
Ágasegyháza 23B	2,0	8,4		
Kunbaracs 19B	0,5	2,1		
Lajosmizse 3H	4,1	16,8		
Csongrád 903A	1,0	4,2		
Szentkirály 902A	1,5	6,4		
Total Észak-Kiskunsági Erdészet	*14,9*	*40,0*	*20,4*	*2,0*
Forestry Direction Császártöltés (Császártöltési Erdészet)				
Császártöltés 114D	4,3	6,0	12,0	
Hajós 152C	0,7	3,0		
Hajós 197E	0,5	2,2		4,0
Kecel 14I	0,5	2,0		
Kéleshalom 125C	1,7	2,8	4,2	
Kéleshalom 129C	3,1	5,0	8,0	
Total Császártöltési Erd.	*10,8*	*18,0*	*24,2*	*4,0*
Forestry Direction South-Kiskunság (Dél-Kiskunsági Erdészet)				
Harkakötöny 74C	0,5	1,0	1,0	
Harkakötöny 14A	0,8	3,5	3,8	
Harkakötöny 63I	0,5	2,15		
Kömpöc 12A	4,4	6,35	12,0	
Balotaszállás 149K	5,6	10,0	13,5	
Total Dél-Kiskunsági Erdészet	*11,8*	*23,0*	*30,3*	

Forestry Direction Bugac (Bugaci Erdészet)				
Bócsa 5I	2,0		8,2	
Bócsa 6B	1,0	1,7	2,5	
Bócsa 23F	0,9		3,7	
Bócsa 2E	3,0		12,6	
Bócsa 3A	5,5		23,1	
Bócsa 3C	1,5		6,3	
Bócsa 3H	1,8		7,6	
Orgovány 3A	1,0		4,2	
Orgovány 4B	1,7		7,2	
Bugac 142D	2,3	9,7		
Bugac 142C	0,6	2,5		
Bugac 137D	4,2	5,9	11,8	
Jakabszállás 9C	1,9	3,8		
Jakabszállás 21F	0,3	1,3		
Jászszentlászló 8E	3,3		13,9	
Petőfiszállás 650C	2,1	8,8		
Total Bugaci Erd.	*33,1*	*33,7*	*101,1*	
Total KEFAG Co. 2004. spring (tavasz)	*70,6*	*114,7*	*176,0*	*6,0*

Table 3 Reforestation made by the Forest Enterprise KEFAG Co. with mycorrhized seedlings in spring 2004
(A KEFAG R.T. területén, mikorrhizált csemetékkel végzett erdősítés 2003. őszén)

No of the sample Lab. szám	The name of the sample A minta jele	N %	P %	K %	Ca %	Mg ppm	Zn ppm	Mn ppm
16342	Akác k. (Black locust)	2.98	0.28	0.56	4.16	0.50	20	59
16343	Akác M-cs (Black locust)	3.02	0.28	0.65	4.17	0.44	25	68
16344	Akác M-m (Black locust)	3.66	0.22	0.87	4.10	0.41	55	72
16345	Fehér nyár k. (White poplar)	3.07	0.66	1.08	1.61	0.27	69	77
16346	Fehér nyár M-cs (White poplar)	3.10	0.66	1.33	1.58	0.29	43	74
16347	Fehér nyár M-m (White poplar)	3.41	0.77	1.17	1.70	0.32	46	92
16348	Cser k. (Quercus cerris)	2.19	0.28	0.45	1.43	0.42	23	31
16349	Cser M-cs (Quercus cerris)	2.23	0.28	0.73	1.55	0.26	25	70
16350	Cser M-m (Quercus cerris)	2.50	0.33	0.79	1.18	0.35	45	56
16351	Magas kőris k. (Fraxinus excelsior)	2.79	0.25	0.60	2.61	0.63	18	38
16352	Magas kőris M-m (F. excelsior)	3.27	0.28	1.10	2.42	0.55	28	69
16353	Fehér nyár k (White poplar).	2.99	0.66	1.29	1.45	0.32	209	58
16354	Fehér nyár M-m (White poplar)	3.61	0.82	1.17	1.21	0.29	302	79

Key to the signs used (Jelmagyarázat): k – control (kontroll)
M-m – Mycorrhozed by dipping (*M*ikorrhizált helyszíni *M*ártogatással)
M-cs – Mycorrhized in the nursery (*M*ikorrhizált *c*semetekerti Talajoltással)

Table 4 The effect of the mycorrhiza on the nutrition contents of the seedling after the first vegetation period (A mikorrhiza hatása az erdősítésbe kiültetett csemeték tápanyag tartalmára az 1. tenyészeti időszak végén) (SZBKI Központi Laboratórium, Kecskemét 2004)

CONCLUSIONS

The analysis of nutrition contents of the leaves of mycorrhized plants has proved our expectation and his results are in agreement with the data of MOUSSAIN et al. 1979 (ited in 10).

We hope that using mycorrhized plants for the reforestations and for the afforestations, we can partly establish healthier forest ecosystems and more productively wood stands, partly may decrease the total costs of afforestations because it will be no need to repeat the plantations.

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