Ann. Sci. For. (1989) 46 suppl., 762s-764s
Forest Tree Physiology, E. Dreyer *et al.*, eds.

Experimental weathering of mica by mycorrhizal and non-mycorrhizal beech and pine

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Introduction

Ectomycorrhizal fungi are able in pure culture to release organic acids and to solubilize insoluble minerals, such as insoluble phosphates (Leyval and Berthelin, 1986). However, in symbiotic conditions, in plant rhizosphere, their effect on the weathering of minerals has not yet been studied to any great extent.

A lysimeter experiment was performed in a greenhouse to study the influence of *Laccaria laccata* mycorrhization on the weathering of phlogopite, a ferro-magnesian mica, in pine (*Pinus sylvestris* L.) and beech (*Fagus silvatica* L.) rhizospheres.

Materials and Methods

Six month old pine and beech seedlings were grown on sand in lysimetric cylinders (Leyval, 1988, 1989). They were inoculated or not with the ectomycorrhizal fungus, *L. laccata*. Phlogopite particles, mixed with the sand, were the only source of Mg, Fe and Al, and the partial source of K for plant nutrition. Cylinders with plants and control cylinders without plants were fed automatically with a nutrient medium.

After 2 yr, dry weight of plants and their uptake of mineral elements were determined (Leyval, 1988, 1989). Phlogopite transformation was observed by means of chemical analyses, X-ray diffraction analysis and scanning electron microscopic observations combined with a microprobe (Leyval, 1988). Mineral element (Mg, Fe and Al) mobilization from phlogopite was indirectly evaluated by adding the quantities absorbed by plants and the amounts released in the collected nutrient solution.

Results

X-ray diffraction diagrams (Fig. 1) show a mineralogical transformation of phlogopite into the clay vermiculite (appearance of a peak at 14 Å). This transformation was observed only in the rhizosphere and was greater in pine rhizosphere than in beech rhizosphere (Fig. 1). No differences between mycorrhizal and non-mycorrhizal plants appeared according to these diagrams. However, in the rhizosphere of mycorrhizal pines, significant losses of potassium from phlogopite particles were observed in comparison to control phlogopite and to non-mycorrhizal treatments (Table I).

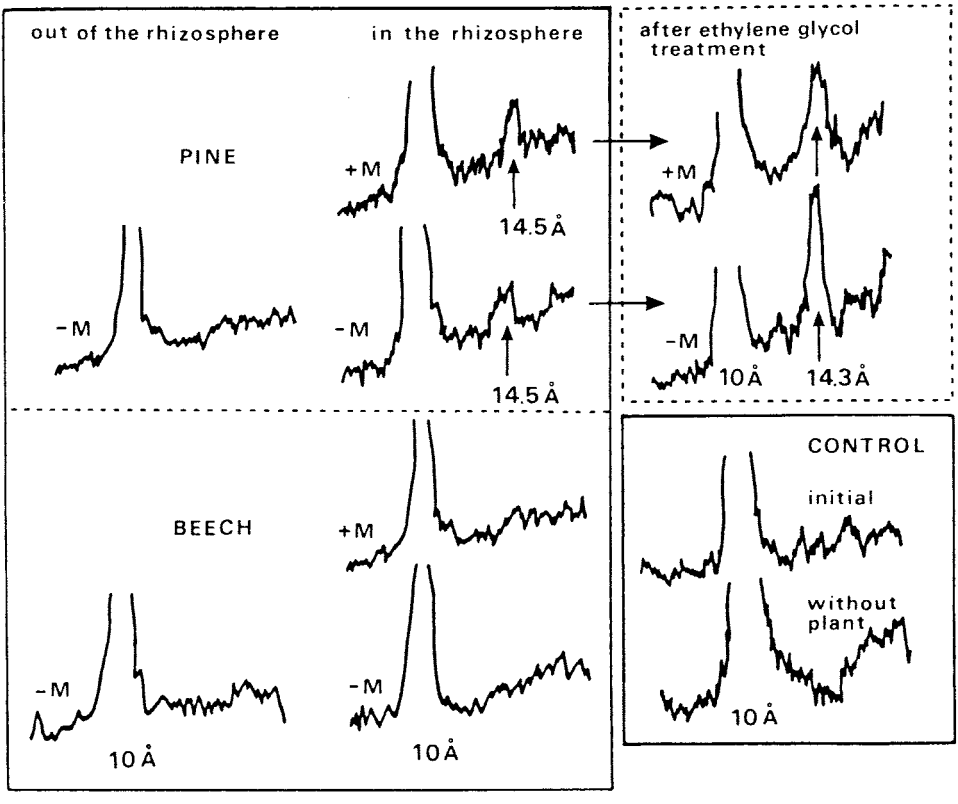

Fig. 1. X-ray diffraction diagrams of phlogopite grains collected after 2 yr in or out of the rhizospheres of pine and beech seedlings. –M: non-mycorrhizal plants, +M: mycorrhizal plants.

Table I. Relative losses of K and Fe from phlogopite flakes as determined by X-ray emission analysis.

Flakes	*K/Si*	*Fe/Si*
Control	1.93a	1.62a
Beech rhizosphere		
–M	nd	nd
+M	1.64a	1.15a
Pine rhizosphere		
–M	2.15a	1.67a
+M	0.08b	1.22a

Numbers followed by the same letter in each column do not differ significantly at $P = 0.01$; nd: not determined; –M: non-mycorrhizal plants, +M: mycorrhizal plants.

The total amounts of Mg, Fe and Al mobilized were also larger in pine lysimeters than in beech lysimeters. Mycorrhizal beeches mobilized greater amounts of Mg, Fe and Al than non-mycorrhizal beeches, but mycorrhization of pine seedlings only promoted Fe mobilization (Table II).

Discussion and Conclusion

Geochemical and mineralogical transformations of phlogopite were observed in

Table II. Mobilization (mg/plant) of Mg, Fe and Al from phlogopite by mycorrhizal and non-mycorrhizal pine and beech seedlings after 2 yr.

		Beech		*Pine*		*Control*
		–M	*+M*	*–M*	*+M*	
Dry weight (mg/plant)		1.4a	4.0b	6.9c	5.9c	
Mineral element mobilization (mg/plant)	Mg	1.8	4.9	8.6	7.6	0.8
	Fe	0.8	4.1	8.3	9.6	0
	Al	7.5	11.3	17.1	14.1	4.5

Mobilization is the total of plant content and quantity recovered in nutrient solution.

the lysimeters after 2 yr. Phlogopite weathering (transformation into the clay vermiculite, losses of K, Fe and Mg) occurred only in the rhizosphere and was greater in pine rhizosphere than in beech rhizosphere, which could be explained by the greater amount of organic acids released into the rhizosphere by pine roots (Leyval, 1988).

The inoculation of roots with *L. laccata* increased Mg, Fe, Al and K mobilization from the mineral and losses of K in pine rhizosphere.

Under our experimental conditions, *L. laccata* promoted beech growth but did not show a significant effect on pine growth. Mycorrhizal plants did not seem to release more organic acids, although this fungus acidified a liquid medium in pure culture (Leyval and Berthelin, 1986; Leyval, 1988). The *L. laccata* effect on phlogopite weathering could also be an indirect one, attributed to the increased plant growth and to the increased soil exploration, because the rhizospheric soil, expressed as a percentage of the total soil, was 2 times larger for mycorrhizal plants than for non-mycorrhizal plants, respectively 5–9.2% and 1.6–5.8% of the total soil weight (Leyval, 1988).

References

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