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Influence of Herbicides on VA Mycorrhizal Propagation in Soil*

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Abstract

The impact of different herbicides and metal copper ions on the growth of VA mycorrhizal mycelium in soil and the infection of host roots was investigated. Xenobiotics were applied at doses recommended for standard practice in agriculture. The speed of VA hyphae extension from one host plant to another was taken as a quantitative measurement for mycorrhizal propagation in natural soils. For this reason a cuvette system was developed to study hyphae proliferation through soil regions containing different xenobiotics. In the cuvettes, plants were separated by a root-free section of sterilized soil containing the test substances. The fungus had to grow through these rootless soil parts to reach and colonize new host plants, which were examined for mycorrhizal infection after different time periods.

The method was found to be sensitive to evaluate side effects of pesticides when compared to results from classical pot culture biotests. In the cuvettes, growth of sensitive mycorrhizal species was retarded by some herbicides even under recommended application dosage.

Introduction

Vesicular-arbuscular mycorrhizal fungi are present in almost every natural soil-ecosystem. Their positive effect on host plant growth and stress resistance, even under favourable nutrient conditions in cultivated soils has been well demonstrated (Harley and Smith 1983). However agricultural practices, specially the use of pesticides, can influence nontarget organisms in the rhizosphere and may affect mycorrhizal formation in the soil. Retardation or inhibition of mycorrhizal fungi and a shift in mycorrhizal species combination in soil, induced by pesticides, can be of great ecological significance for soil fertility and plant production. Specially herbicides directly applied on the soil surface can have considerable effects on mycorrhizal formation (Sieverding 1984). Since not all mycorrhizal species form effective and biological active symbioses, differences in efficiency of the symbiosis may be due to host plant compatibility as well as to differential sensitivity of fungal species in a population to various pollutants. By

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studing specific processes of growth and development of mycorrhizal species in contaminated soils, we attempted to evaluate critical side effects of pesticides on soil microorganisms. In order to evaluate effects of herbicides and heavy metals on mycorrhizal development, biotests were performed with pot cultures and with a new cuvette technique (Schüepp et al. 1987).

Materials and Methods

Effects of xenobiotics were tested on three mycorrhizal species of fungi belonging to the genera *Glomus* (*Gl. fasciculatum, Gl. etunicatum and Gl. mosseae*). The rate of infection was estimated using a one to five scale (0 = no mycorrhiza evidence/5 = heavily infected root) or expressed in percentage of root infection. The soil used was a loamy sand soil with a low available P content (15 ppm) and was sterilized previously by gamma radiation.

Two methods were compared. In a pot culture study, plants were transfered, after germination on sterile substrate, to a soil previously sieved and sprayed with a solution of the given xenobiotic substance and inoculated with the mycorrhizal fungi after the method of Dehne and Backhaus, 1986. The quantity of substances sprayed per kg soil was computed on the basis of the recommended dose per ha for each substance, assuming an homogenious mixing of the 10 upper cm of soil.

For comparison xenobiotic substances were sprayed in a field experiment at the recommended dose. A two centimeter thick monolith of such treated soil was transferred in a cuvette, and placed between two other cuvette sections, containing a xenobiotic-free soil and the indicator plants. In one cuvette the "spreader" plant was inoculated with VAM fungi, while the "receiver" plant in the other cuvette was VAM free. Polyamid nets, penetrable for mycorrhizal hyphae but not for plant roots, separated the soil monolith from these two compartments. "Receiver" plants were analysed for mycorrhizal infection after 5 and 8 weeks. The kinetics of VAM propagation was related to the degree of soil contamination with xenobiotics.

Results and Discussion

In pot culture tests xenobiotic substances applied once at the recommended rate were found to have little detrimental effect on the VAM population density of maize plants (Table 1, col. 3). However a five times larger application dose (or a repetition of the recommended application, data not shown) induced, for most herbicides, a significant reduction of plant colonization by VAM fungi (Table 1, col. 4). Dinoseb, a herbicide known to be highly toxic for earth worms and soil microfauna, was found to have only little effect on VAM. On the other hand EPTC (EPTAM) and MCPP

Table 1. Shoot dry weight and % of roots infected by VAM fungi of maize plants after a 6 weeks growing period in soil amended with various herbicides either at their recommended dose (D), or with a five times overdose (5D).

Treatment	Recommended Application Dose (D), (kg AJ/ha)	VAM-infection (% infection)		Shoot dry weight (g) average of 8 repetitions	
		D	5D	D	5D
2.4 D	1.2	82a	65bc†	32.2	31.0
DiQUAT	1.6	76ab	55c	28.4	27.5
MCPP	2.1	35d	3f	25.4	8.6*
ATRAZIN	1	90a	85a	34.2	33.6
LINURON	1.5	63bc	45d	31.6	32.4
DINOSEB	3	71b	59bc	29.6	28.8
EPTC	7.2	39d	20e	29.5	18.2*
ALACHLOR	4.8	74ab	48c	30.4	24.5
PROPACHLOR	5.2	76ab	61bc	31.2	30.6
CONTROL	—	78a	78a	32.6	32.6

† letters of a statistical Duncan test. Numbers followed by the same letter do not differ significantly from each other at the $p=0.5$ level.

*Phytotoxicity caused by herbicide application.

(MECOPROP) led to a strong reduction of VAM propagation even at recommended application doses.

Biotests with cuvettes were found to be a more sensitive method for evaluating side-effects of pesticides on mycorrhiza. The herbicide "ALACHLOR" which shows no effect on Mycorrhiza build-up in pot culture tests causes a depression of hyphae growth, studied with the cuvette technique (Fig. 1). Furthermore, with the cuvettes, susceptibility to herbicides appears to differ among species and even among strains. Species, such as *Glomus fasciculatum*, were able to penetrate cuvettes rapidly (see control, Fig. 1), but were significantly affected by the presence of ALACHLOR. On the other hand *Glomus etunicatum*, a more slowly growing fungal species, is only slightly affected by the same herbicide, (Fig. 2). A reduction in root colonization of "receiver plants" in the cuvette system could also be observed with copper sulfate, while pot culture tests with copper in the same concentration showed no effect on mycorrhiza (data not shown).

It appears that exposed fungal mycelium in a root-free soil section is much more affected by xenobiotics than an established mycorrhiza formation on host roots. This could be of great ecological significance for fungal propagation in contaminated natural soils. Futher investigations would be necessary to elucidate to what extend indirect effects are also included. Xenobiotics can indeed change microbial populations and activities in the soil, which might in turn influence mycorrhizal spread and development.

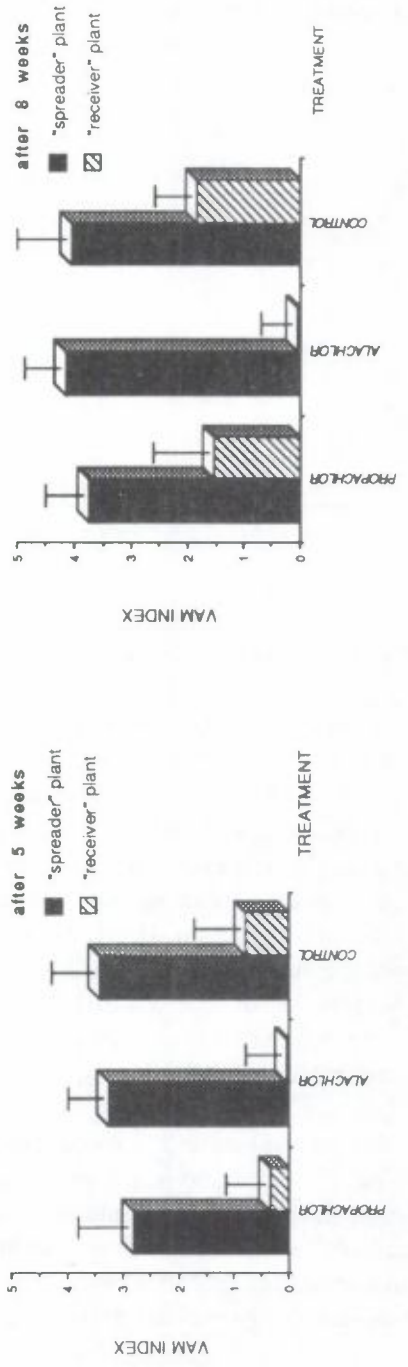

Figure 1. Root colonization by the VAM fungus *Glomus fasciculatum* of "spreader" and "receiver" maize plants separated by a soil monolith. Monoliths were sprayed in field experiments with either of two herbicides according to recommendation.

Figure 2. Root colonization by the VAM fungus *Glomus etunicatum* of "spreader" and "receiver" maize plants separated by a soil monolith. Monoliths were sprayed in field experiments with either of two herbicides according to recommendation.

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