Effects of sewage sludge application on the arbuscular mycorrhizal colonization of selected grassland species in Austria

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ABSTRACT

A long-term field experiment was conducted to study the effects of sewage sludge application on the arbuscular mycorrhizal (AM) root colonization of 14 selected grassland species. The sewage-sludge-treated soil was enriched primarily with inorganic P, lactate-soluble K, aqua regia-extractable Ca and Mg as well as aqua regia-extractable heavy metals (Zn, Cu, Cd, Pb, Hg) in the uppermost 10 cm. In the sewage-sludge-treatment and in the untreated control percentage AM root colonization of the grassland species investigated varied from 17 to 45 %. In the sewage-sludge-treated soil mycorrhization was highly significant lower than in the unfertilized soil. The results suggest that a long-term application of sewage sludge leads to a decrease in percentage AM root colonization of grassland species primarily due to a P accumulation in the soil.

KEYWORDS: mycorrhiza, field experiment, phosphorus, heavy metals

INTRODUCTION

The aim of this study was to assess the effects of sewage sludge application on the arbuscular mycorrhizal (AM) root colonization of 14 selected grassland species.

METHODS

For this purpose a long-term field experiment was conducted at the AREC Raumberg-Gumpenstein (Styria, Austria). The experimental site (700 m a.s.l.) has a relatively cool and humid climate with a mean annual temperature of 6.9 °C and annual precipitation of 1035 mm. The soil was a deep, well-drained, non-calcareous Cambisol with a loamy sand texture. The plant stands were classified as *Alchemillo monticolae-Arrhenatheretum elatioris*. The field experiment included a sewage-sludge-treatment and an untreated control each with four replicates. Sewage sludge from the City of Graz was used. The annual application rate was 7.5 t ha^{-1} for a period of 10 years. As a result of the long-term applications of sewage sludge to a nutrient-poor grassland soil (particularly low K content), the topsoil was enriched primarily with inorganic P, lactate-soluble K, aqua regia-extractable Ca and Mg as well as aqua regia-extractable heavy metals (Zn, Cu, Cd, Pb, Hg). In the uppermost 5 cm the main differences between the sewage-sludge-treated soil and the unfertilized soil were: pH in a $CaCl_2$-solution (7.0 vs. 6.4), lactate-soluble K content (201 vs. 32 mg kg^{-1}), water-extractable P content (24 vs. 6 mg kg^{-1}), lactate-soluble P content (283 vs. 34 mg kg^{-1}) and total P (2181 vs. 1344 mg kg^{-1}). In contrast, organic P as a percentage of total P was lower in the sewage-sludge-treated soil (31 %) in comparison with the unfertilized soil (53 %). Therefore, accumulation of P due to long-term applications of sewage sludge occurred mainly in inorganic form. Comparable results were found for the 5-10 cm soil layer. Harvestable above-ground phytomass and below-ground phytomass (0-30 cm of soil depth) were higher in the sewage-sludge-treatment than in the untreated control. Mineral nutrients and heavy metals in the plant biomass were determined by using standard methods. AM root colonization

was estimated according to the method of Vierheilig et al., 1998. SPSS was used for statistical analysis of the data.

RESULTS AND DISCUSSIONS

The degree of mycorrhization of 14 selected grassland species is shown in Table 1. Percentage AM root colonization varied between different grassland species, even in the same treatment. Variability between replicates was marginal. The degree of root infection, ranging from 17 to 45 % within both treatments, was highly significant influenced by the applications of sewage sludge (Wilcoxon-test, P = 0.001). Except for *Cardamine pratensis, Phleum pratense* and *Trisetum flavescens*, all grassland species investigated showed a lower percentage AM colonization of their roots in the sewage-sludge-treated soil than in the unfertilized soil. In the harvestable above-ground phytomass as well as in the leaves of *Plantago lanceolata, Leontodon hispidus, Arrhenatherum elatius* and *Trisetum flavescens* differences in the concentrations of P, Zn, Cu, Cd, Pb and Hg between the two treatments were small in spite of considerably differences in the soil. Only in the below-ground phytomass the concentrations of P, Zn, Cu, Cd and Pb were higher in the sewage-sludge-treatment than in the untreated control. In the harvestable above-ground phytomass, in the below-ground phytomass and in the leaves of all plant species investigated, except one, K concentration was comparatively higher in the sewage-sludge-treatment (data not shown). It is well known that high soil-P levels can inhibit root infection with arbuscular mycorrhizas (Marschner 1998). Thus, it seems likely that the much higher inorganic P level in the sewage-sludge-treated soil was associated with a greater P concentration mainly in the roots of the grassland species, leading to a decrease in mycorrhization.

REFERENCES

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Table 1. Degree of mycorrhization of selected grassland species in an unfertilized soil (0) compared with a sewage-sludge-treated soil (7.5 t ha^{-1} yr^{-1}).

	0			7.5 t ha^{-1} yr^{-1}		
	n	AM %	V %	n	AM %	V %
Ajuga reptans	10	37	6	10	29	8
Anthoxanthum odoratum	10	35	7	10	30	6
Arrhenatherum elatius	34	36	7	28	28	10
Cardamine pratensis	10	18	13	10	18	9
Cardaminopsis halleri	34	22	9	34	17	10
Dactylis glomerata	16	19	7	16	17	12
Leontodon hispidus	44	25	11	38	20	10
Phleum pratense	10	22	10	10	24	13
Plantago lanceolata	44	40	6	32	31	7
Poa pratensis	6	39	5	8	33	5
Ranunculus acris ssp.acris	20	26	9	20	21	7
Taraxacum officinale agg.	24	45	5	18	33	6
Trifolium pratense ssp.pratense	18	22	9	18	18	11
Trisetum flavescens	38	20	8	34	20	10

n = number of plants investigated; AM % = mean percentage arbuscular mycorrhizal root colonization; V % = variation coefficient in %