

**ZINC ACCUMULATION AND  
TRANSLOCATION IN *SOLANUM  
NIGRUM*: EFFECT OF ARBUSCULAR  
MYCORRHIZAL FUNGI AND MATRIX  
CONCENTRATION**

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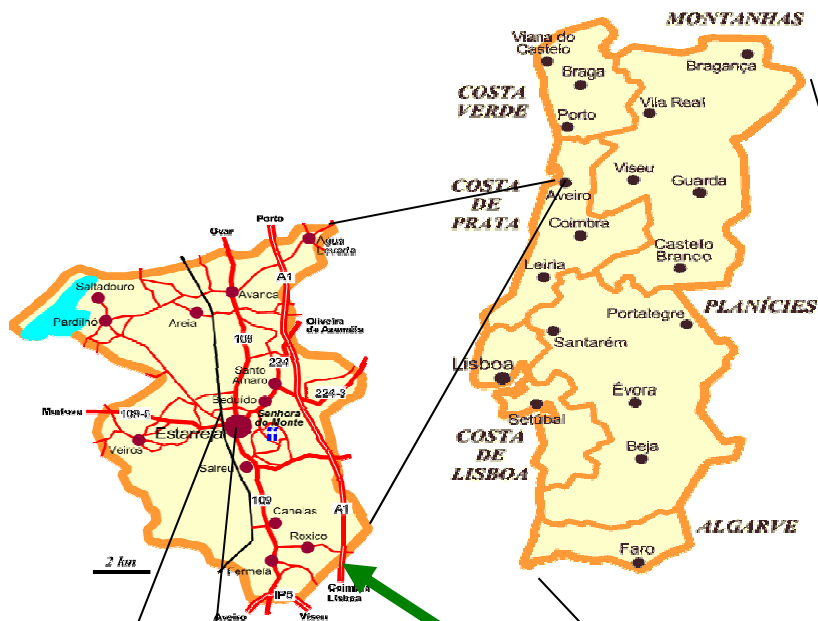
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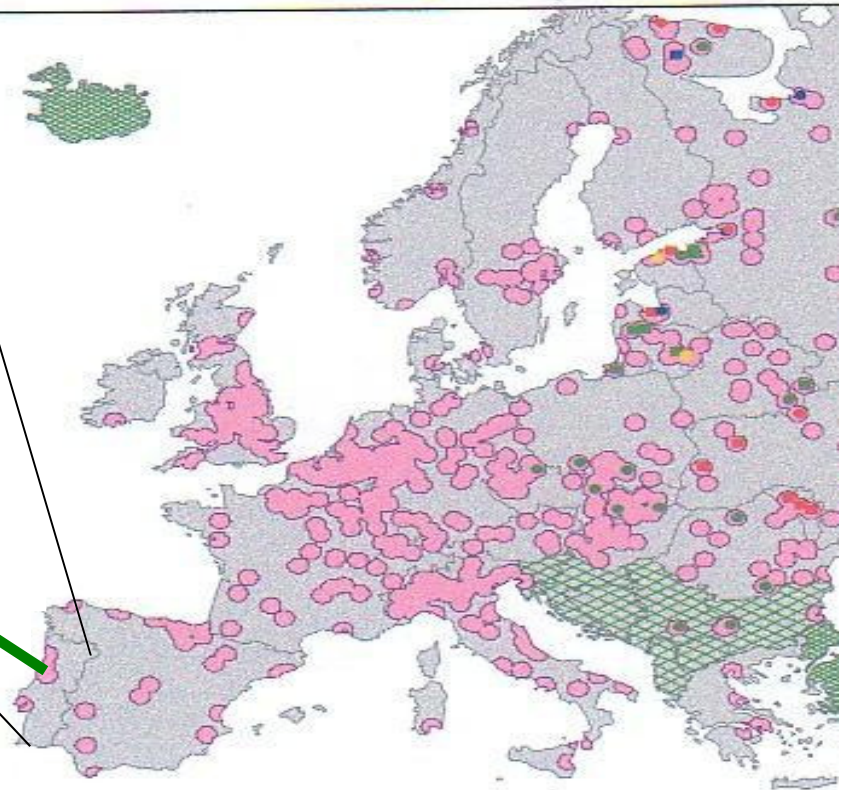
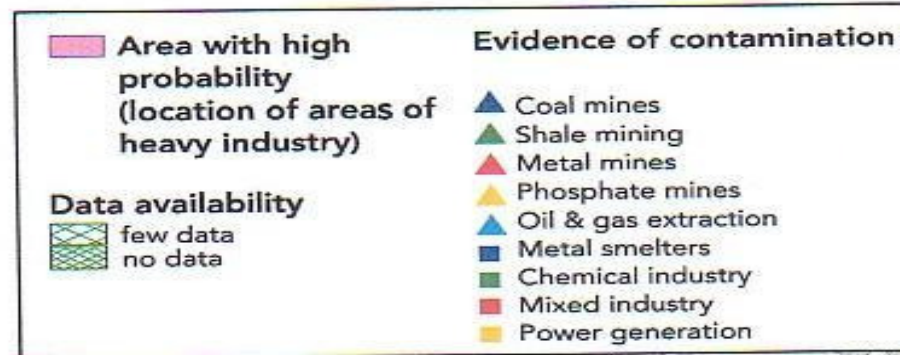


Plant species colonising contaminated soils are potential metal accumulators and may be very useful for **PHYTOREMEDIATION** strategies (Álvarez et al., 2003).

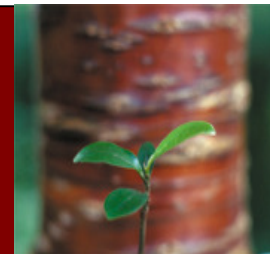
# Heavy metal contaminated sites in Portugal



Estarreja



# Estarreja: Situation analysis



- ↪ Discharge of solid residues in the surrounding area
- ↪ Conducting of industrial wastewaters into a stream nearby (“**Esteiro de Estarreja**”)
- ↪ High permeability of the soils

## Total metal in the banks (mg kg<sup>-1</sup> soil)

Zn	898.9 (125-3 620)
Pb	835.4 (16- 3740)
Hg	66.6 (0.3- 275)
As	1495 (45-5 620)



# Plant survey in “Esteiro de Estarreja”



714 mg Zn kg<sup>-1</sup>

*Rubus ulmifolius*



374 mg Zn kg<sup>-1</sup>

*Phragmites australis*



599 mg Zn kg<sup>-1</sup>

*Convolvulus* sp.



*Solanum nigrum*



1130 mg Zn kg<sup>-1</sup>

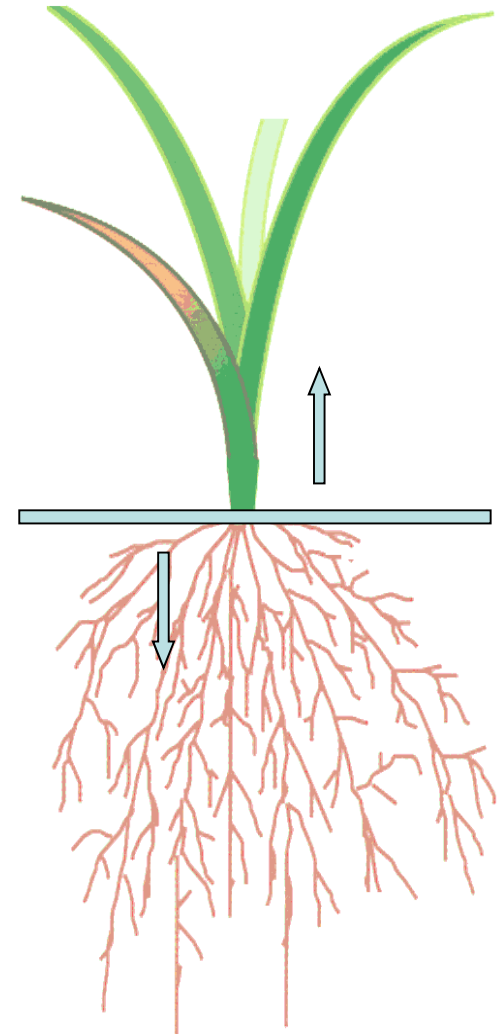
# Arbuscular mycorrhizal fungi



- ↪ Soil microorganisms
- ↪ Form symbiotic associations with plant roots
- ↪ Receive carbohydrates from associated plants
- ↪ Capture mineral nutrients from soil ⇒ plant growth is improved



**May also influence heavy metal uptake**



## Aims of the study



Assess the influence of Zn and of different AMF isolates on *S. nigrum* :

- ✓ metal uptake and accumulation
- ✓ growth
- ✓ metal translocation from root to the aboveground parts

# Experimental design



Zn= 0 mg kg <sup>-1</sup> dry sand					
fungus A	fungus B	fungus C	fungus D	Mixture	No fungi

Zn= 100 mg kg <sup>-1</sup> dry sand					
fungus A	fungus B	fungus C	fungus D	Mixture	No fungi

Zn= 500 mg kg <sup>-1</sup> dry sand					
fungus A	fungus B	fungus C	fungus D	Mixture	No fungi

Zn= 1000 mg kg <sup>-1</sup> dry sand					
fungus A	fungus B	fungus C	fungus D	Mixture	No fungi

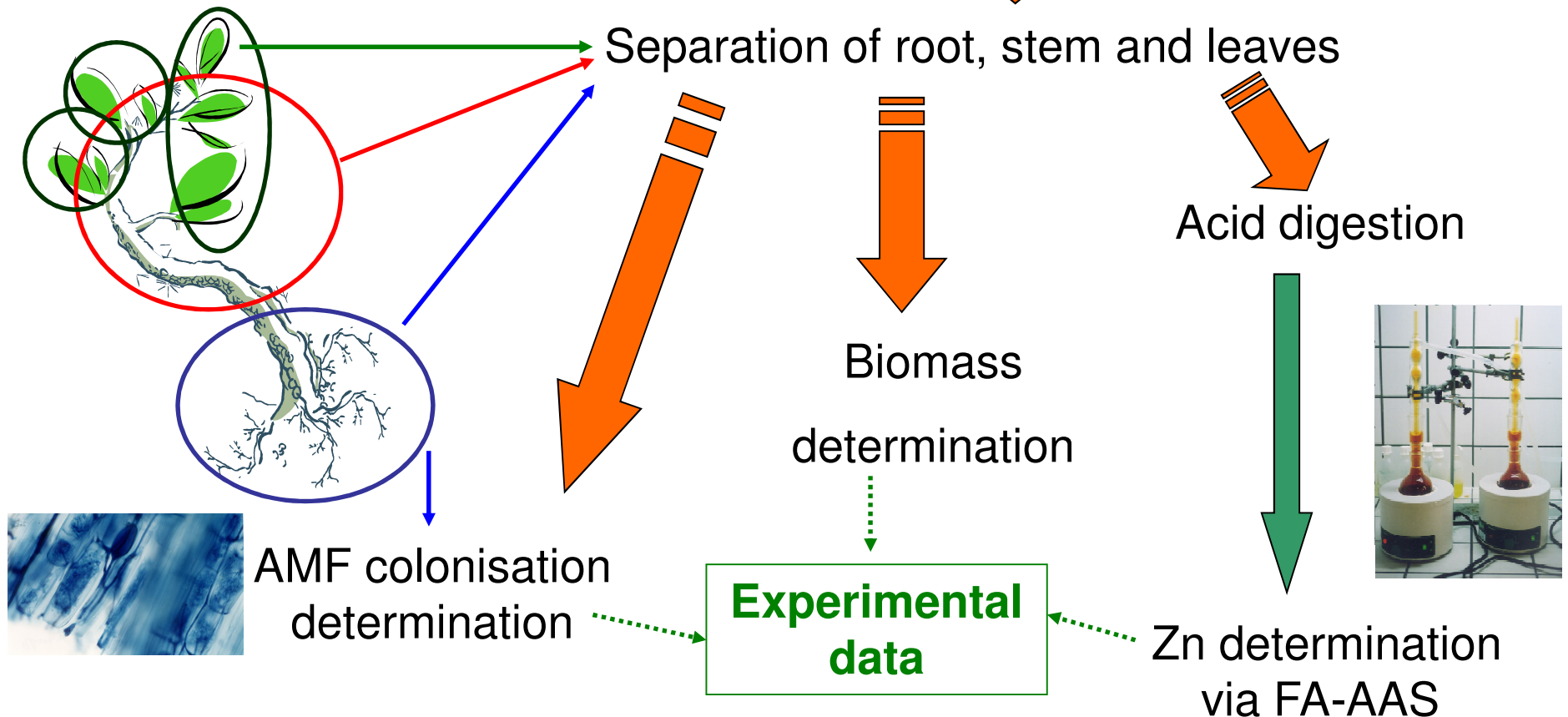


fungus A - *Glomus* sp. BEG140 (isolated from a Mn contaminated soil); fungus B - *Glomus claroideum* (isolated from a Cd and Zn contaminated soil); fungus C - *Glomus mosseae* (isolated from a Cd and Zn contaminated soil); fungus D – *Glomus intraradices* (isolated from a Pb contaminated soil)

# Experimental procedure



Growth of the plants for 25 weeks  
(6 weeks for 500 and 1000 mg kg<sup>-1</sup>  
levels)



# Results: AMF colonisation



AMF	Zn (mg kg <sup>-1</sup> )			
	0	100	500	1000
<i>G. sp. BEG140</i>	9.3 ± 0.8 <sup>c</sup>	9.1 ± 0.5 <sup>bc</sup>	4.9 ± 0.5 <sup>bc</sup>	4.2 ± 0.6 <sup>ab</sup>
<i>G. claroideum</i>	8.4 ± 0.6 <sup>bc</sup>	7 ± 1 <sup>d</sup>	7.1 ± 0.3 <sup>a</sup>	5.0 ± 0.4 <sup>a</sup>
<i>G. mosseae</i>	9.6 ± 0.4 <sup>bc</sup>	8.4 ± 0.4 <sup>c</sup>	5.7 ± 0.8 <sup>b</sup>	4.7 ± 0.8 <sup>a</sup>
<i>G. intraradices</i>	11 ± 2 <sup>ab</sup>	10.2 ± 0.6 <sup>ab</sup>	5.7 ± 0.6 <sup>b</sup>	3 ± 2 <sup>ab</sup>
Mixture	12 ± 2 <sup>a</sup>	10.5 ± 0.7 <sup>a</sup>	4.5 ± 0.6 <sup>c</sup>	3.5 ± 0.7 <sup>b</sup>

Results are expressed as percentual means ± SD (n=6). One way ANOVA was performed for each Zn concentration in the sand. Means in the same column with different letters are significantly different from each other (P<0.05) according to the Tukey test.

**Few significant (P < 0.05) differences in colonisation were found when inoculation was made with different AMF for each Zn treatment**

# Results: AMF colonisation

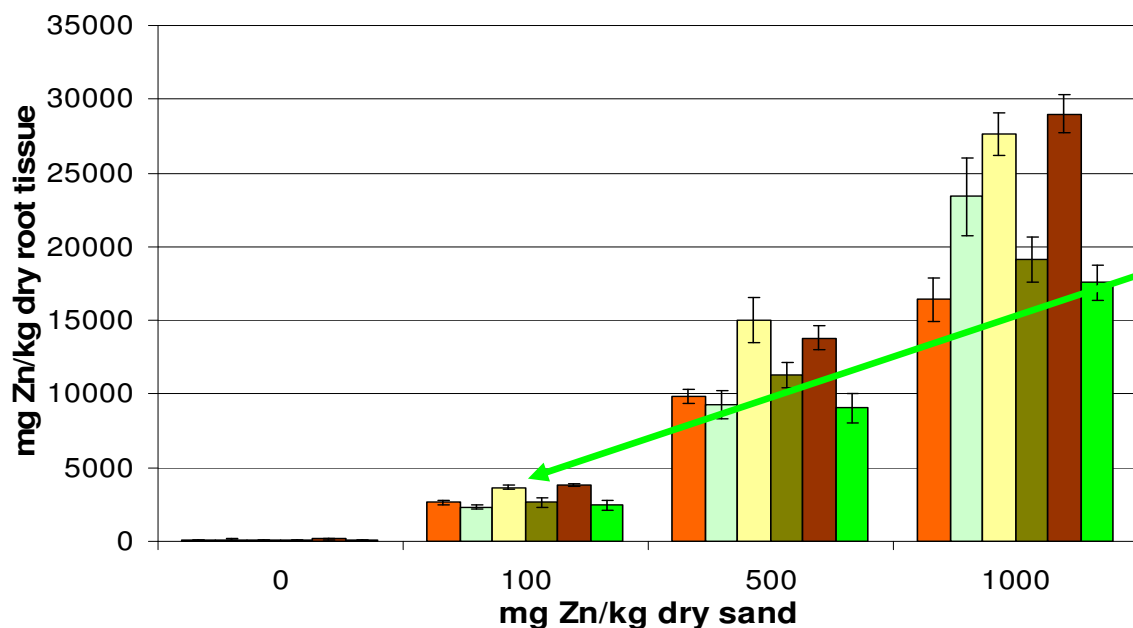
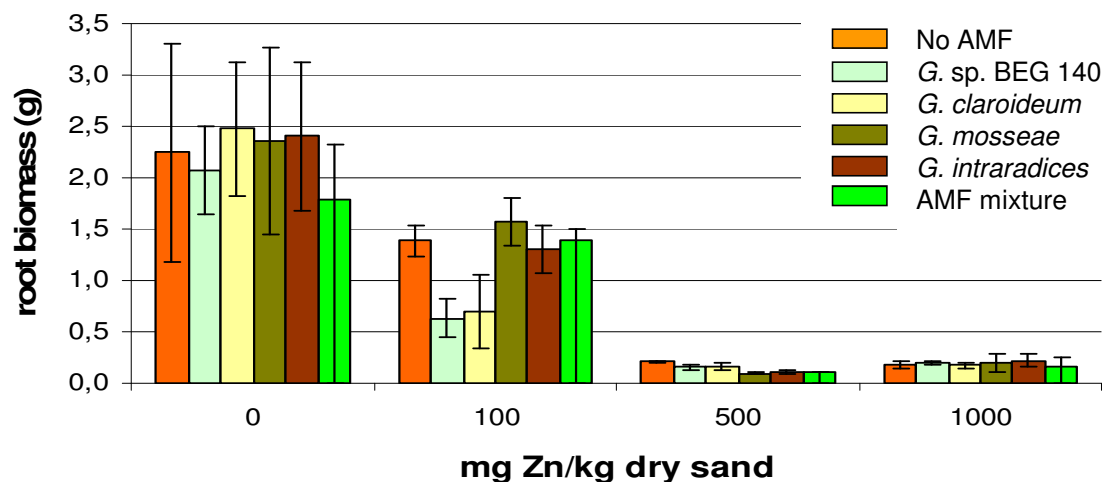


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Results are expressed as percentage means ± SD (n=6). One way ANOVA was performed for each Zn concentration in the sand. Means in the same column with different letters are significantly different from each other (P<0.05) according to the Tukey test.

**The metal concentration induced significant (P < 0.05) differences in the fungi colonisation: higher Zn levels in the matrix resulted in lower percentage mycorrhizal colonisation in *S. nigrum*.**

# Results: Root biomass and Zn accumulation



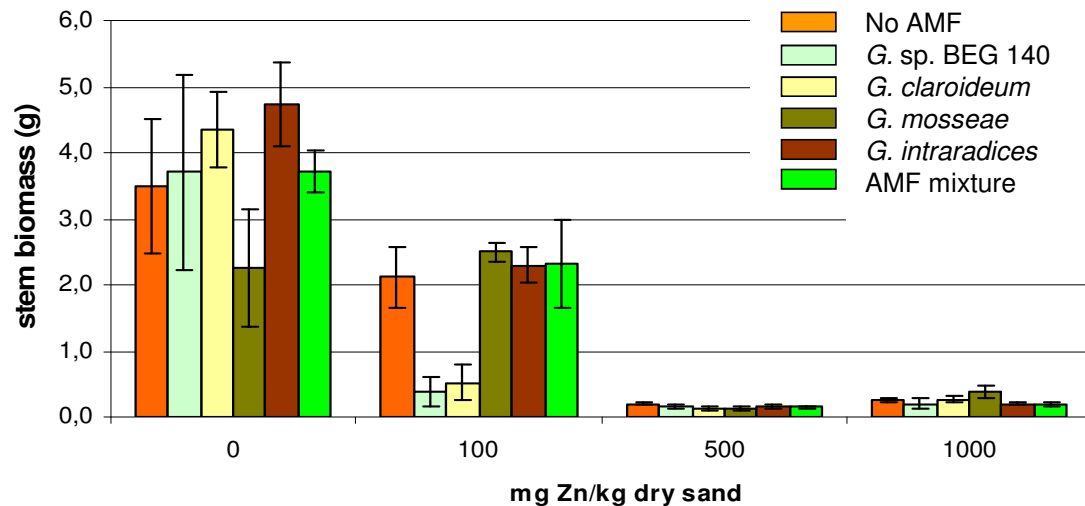
➤ AMF did not affect significantly root biomass

➤ Higher concentration of Zn in the sand matrix resulted in higher Zn accumulation

➤ *S. nigrum* roots accumulated up to 3810 mg Zn kg<sup>-1</sup> with no visual toxicity signs

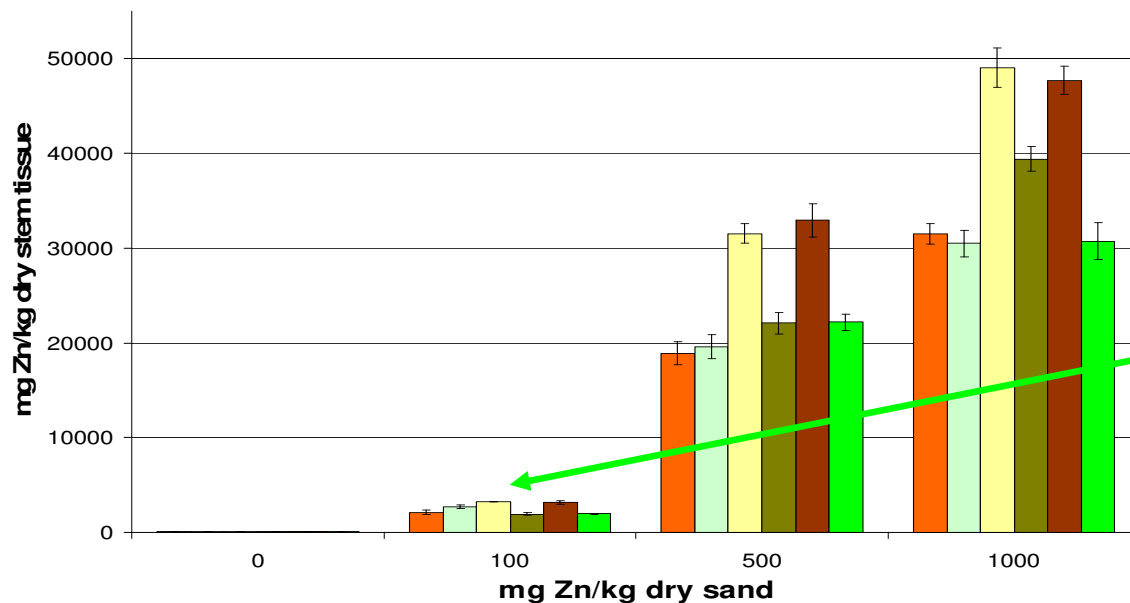
➤ The inoculation with *G. intraradices* and *G. claroideum* led to significantly higher Zn accumulation in the roots

# Results: Stem biomass and Zn accumulation



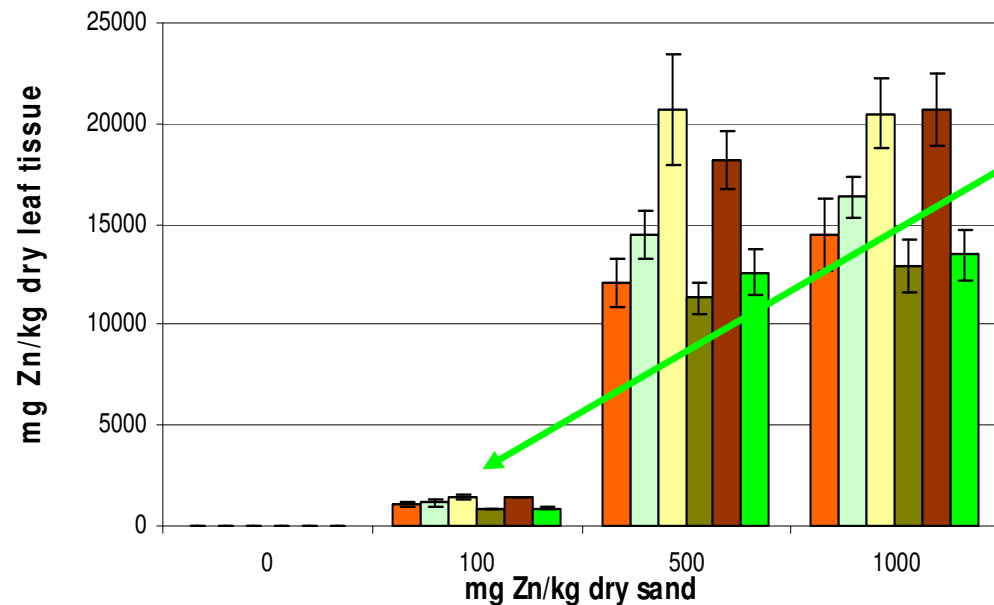
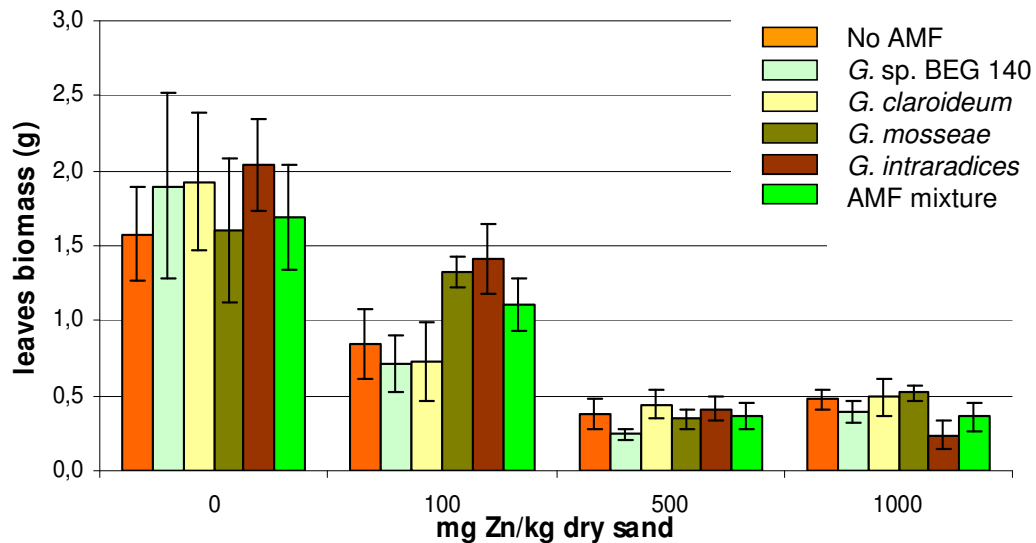
➤ AMF did not affect significantly stem biomass

➤ All the AMF induced significantly higher Zn accumulations in the stem tissue, with the exception of *G. sp. BEG140*.



➤ *S. nigrum* stems accumulated up to 3240 mg Zn kg<sup>-1</sup> with no visual toxicity signs

# Results: Leaves biomass and Zn accumulation



➤ AMF did not affect significantly leaves biomass

➤ *S. nigrum* leaves accumulated up to 1450 mg Zn kg<sup>-1</sup> with no visual toxicity signs

➤ Zn accumulation in the leaf tissues was significantly higher when *S. nigrum* was inoculated with *G. claroideum*, *G. intraradices* and the fungi mixture.

## Results: Enhancement of Zn accumulation



Zn level in the matrix (mg kg <sup>-1</sup> )	Percent increase in the Zn accumulation levels in the tissues (%)	
	<i>Glomus claroideum</i>	<i>Glomus intraradices</i>
100	30	36
500	62	58
1000	53	61

# Conclusions: Zn accumulation



- ↪ Zn accumulation in all tissues was significantly higher when *S. nigrum* was inoculated with *G. claroideum*, *G. intraradices*
- ↪ Higher Zn levels in the sand matrix resulted in higher Zn accumulation in all plant tissues
- ↪ AMF did not affect significantly *S. nigrum* biomass

# Root to Aboveground Translocation



Translocation of the contaminant from the root to the stems and leaves

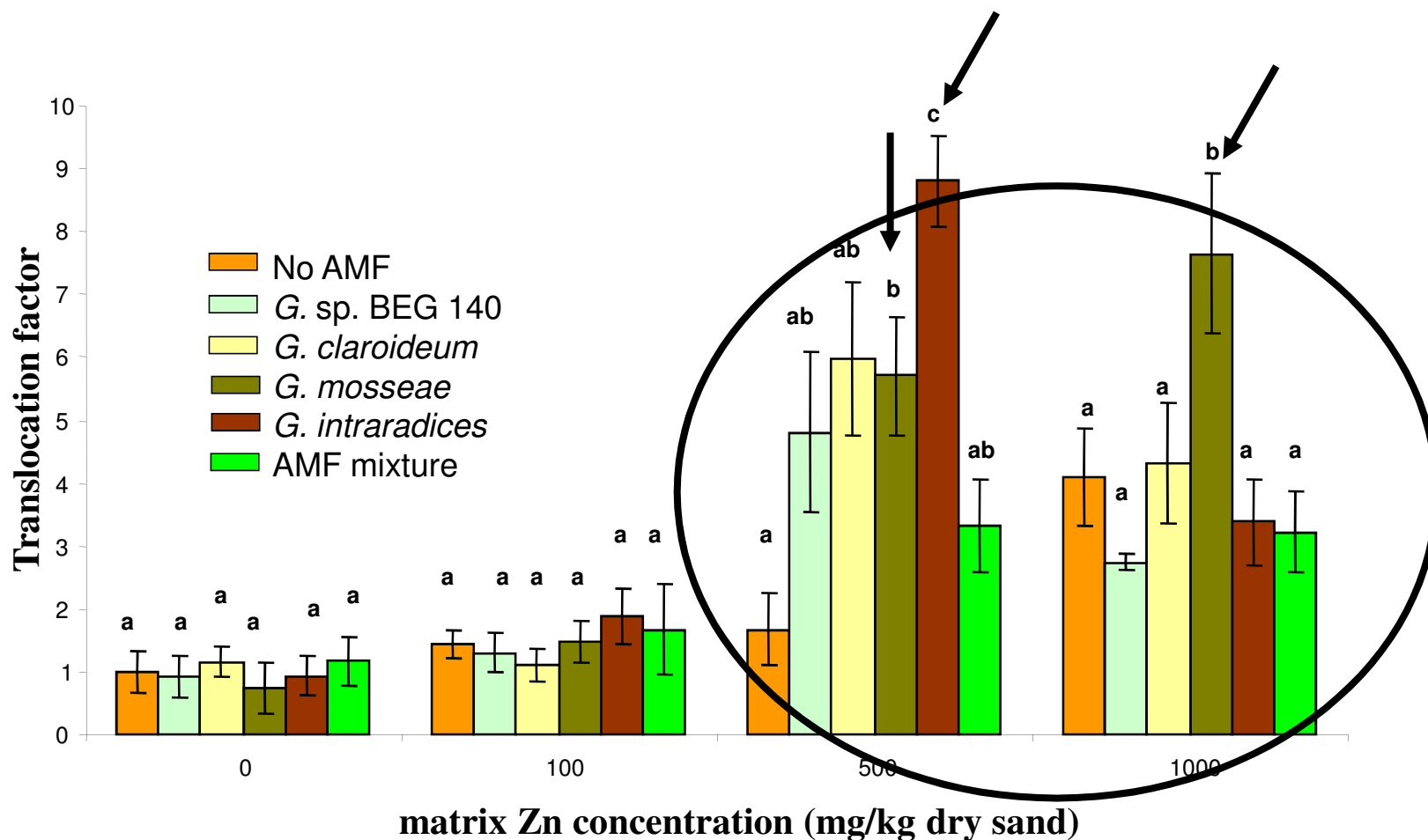


Translocation factor higher than 1 (McGrath and Zhao, 2003).



$$\text{Transfer factor} = \frac{(\text{biomass}_{\text{stem}} \times \text{Zn accumulation}_{\text{stem}}) + (\text{biomass}_{\text{leaves}} \times \text{Zn accumulation}_{\text{leaves}})}{(\text{biomass}_{\text{root}} \times \text{Zn accumulation}_{\text{root}})} > 1$$

# Results: Root to Aboveground Translocation



Bars upon the columns represent  $\pm$  SD. One-way ANOVA was performed for each Zn concentration in the sand. Means in the same concentration group with different letters are significantly different from each other ( $P < 0.05$ ) according to the Tukey test

# Conclusions: Zn translocation



High translocation factors → *S. nigrum* might be a good Zn phytoextractor

The inoculation with AMF resulted, generally, in equal or higher translocations from root to aboveground tissues of *S. nigrum*.

High Zn levels in the sand matrix induced higher translocations



The tested AMF do not seem to act as a zinc barrier in the roots of *S. nigrum*, not restricting their normal translocation to stems

## Final Remarks



↪ The use of *S. nigrum* inoculated with *G. claroideum* or *G. intraradices* appears as a good option for the **decontamination** of polluted **soils** with **low available Zn levels**

↪ At higher contamination levels, higher translocation rates may occur, but at the cost of poor plant biomass development and probable early death of the individuals.

# Aknowledgments

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