APPLICATION OF MANURE AND COMPOST TO CONTAMINATED SOILS AND ITS EFFECT ON ZINC ACCUMULATION BY *SOLANUM NIGRUM* INOCULATED WITH ARBUSCULAR MYCORRHIZAL FUNGI

CATÓLICA
UNIVERSIDADE CATÓLICA PORTUGUESA
ESCOLA SUPERIOR DE BIOTECNOLOGIA

Ana P. G. C. Marques, Rui S. Oliveira, António O.S.S. Rangel, Paula M. L. Castro

Escola Superior de Biotecnologia, Universidade Católica Portuguesa, Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal

PHYTOSTABILISATION: THE APPLICATION OF AMENDMENTS TO ENHANCE PLANT RE-VEGETATION ABILITIES

Phytoremediation can be defined as the combined use of plants, soil amendments and agronomic practices to remove pollutants from the environment or to decrease their toxicity. Addition of organic matter (OM) amendments, such as compost or manure, is an inexpensive practice to facilitate re-vegetation of contaminated soils. Organic amendments can decrease heavy metal bioavailability. Biotic factors, such as symbiotic associations with arbuscular mycorrhizal fungi (AMF) can also affect metal uptake by the plants and improve plant growth, consequently enhancing the re-vegetation abilities of the used plant species.

S. nigrum is an indigenous plant species to a metal polluted site in an industrialised area of Northern Portugal containing sediments with levels of metals above the limits established by EC Directive 86/278/EC, the main occurring metal in those sediments being zinc. Despite this contamination scenario, *S. nigrum* is abundant on the site. Previous studies with this plant showed that *S. nigrum* was able to tolerate high levels of Zn in the soil with no visible toxicity signs. In the present study, the influence of the addition of OM amendments on the growth and metal accumulation by *Solanum nigrum* was assessed in Zn contaminated soils, and the effect of the application of different AMF on the bioavailability of Zn was evaluated. The production of percolates and the corresponding Zn contents was also considered.

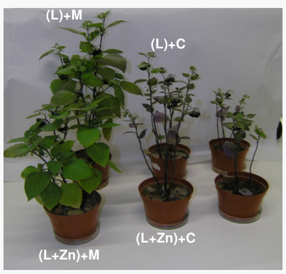
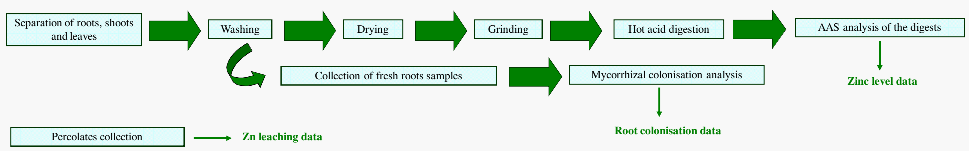


Figure 1: Plant samples grown in local (L) and extra Zn spiked soil (L+Zn)

MATERIALS AND METHODS

The experiment was a factorial design with two matrix Zn levels [contaminated soil from the banks of Esteiro de Estarreja, with 426 mg Zn kg^{-1} dry soil (L) and the same soil after spiking with 500 more mg Zn kg^{-1} dry soil (L+Zn)], three mycorrhizal fungi treatments (no AMF, *Glomus claroideum* and *Glomus intraradices*) and three organic amendment treatments (no addition, 10% compost and 5% manure). Twelve weeks after seeding water was applied to each pot and the percolates were collected individually, procedure that was repeated every 4 weeks until the end of the experiment (t_1, t_2, t_3 and t_4). At harvest soil and plants were collected and analysed.



	AMF species	Zn (mg kg^{-1} dry tissue) leaves				stems				roots			
Local soil													
Control	No fungi	531	±	21	c	1431	±	157	c	1356	±	359	c
	G. claroideum	656	±	35	b	1938	±	134	b	1798	±	148	b
	G. intraradices	851	±	69	a	2482	±	40	a	2687	±	49	a
Compost	No fungi	549	±	61	b	1451	±	198	a	2043	±	104	a
	G. claroideum	558	±	79	b	1280	±	195	a	2040	±	136	a
	G. intraradices	869	±	117	a	1373	±	158	a	2147	±	422	a
manure	No fungi	104	±	23	a	291	±	35	a	573	±	152	a
	G. claroideum	116	±	6	a	409	±	121	a	710	±	54	b
	G. intraradices	105	±	18	a	331	±	64	a	600	±	87	a
Local + Zn soil													
Control	No fungi	1434	±	161	b	3690	±	441	b	5628	±	388	a
	G. claroideum	2542	±	525	a	5446	±	490	a	7465	±	1662	a
	G. intraradices	2082	±	180	a	4423	±	464	b	6399	±	429	a
EDDS	No fungi	877	±	81	b	2942	±	136	a	4657	±	505	b
	G. claroideum	1640	±	111	ab	3203	±	413	a	5977	±	357	a
	G. intraradices	2182	±	846	a	2757	±	265	a	4997	±	326	b
EDTA	No fungi	191	±	34	a	1021	±	94	a	2312	±	403	a
	G. claroideum	208	±	48	a	760	±	86	b	1326	±	225	b
	G. intraradices	233	±	64	a	668	±	72	b	1225	±	164	b

Table 1: Effects of the addition of OM amendments and AMF species on *S. nigrum* Zn accumulation

Means with different letters in the same treatment group are significantly different from each other ($P < 0.05$) according to Tukey test

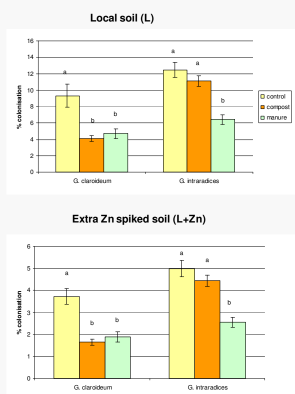


Figure 2: Percentage of mycorrhizal colonisation (%) for *G. claroideum* and *G. intraradices* in *S. nigrum*

Means with different letters for the same AMF are significantly different from each other ($P < 0.05$) according to Tukey test

	Zn (mg/l)			
Local soil	t_4			
L	16	±	2	abc
L+C	18	±	4	a
L+M	17	±	4	ab
L+Sn	5.7	±	0.9	de
L+Sn+Gc	13	±	4	abcd
L+Sn+Gi	14	±	5	abcd
L+Sn+C	8	±	3	de
L+Sn+C+Gc	8	±	1	de
L+Sn+C+Gi	9	±	1	cde
L+Sn+M	9	±	3	cde
L+Sn+M+Gc	9	±	2	de
L+Sn+M+Gi	9	±	2	bcde

	Zn (mg/l)			
Local + Zn soil	t_4			
L+Zn	52	±	22	a
L+Zn+C	48	±	7	a
L+Zn+M	48	±	13	a
L+Zn+Sn	28	±	3	b
L+Zn+Sn+Gc	29	±	2	b
L+Zn+Sn+Gi	33	±	10	ab
L+Zn+Sn+C	31	±	9	ab
L+Zn+Sn+C+Gc	28	±	4	ab
L+Zn+Sn+C+Gi	26	±	5	ab
L+Zn+Sn+M	31	±	5	ab
L+Zn+Sn+M+Gc	29	±	5	ab
L+Zn+Sn+M+Gi	27	±	4	ab

Table 2: Effects of the addition of OM amendments and AMF species on the Zn concentration of the percolates

Means with different letters in the same soil are significantly different from each other ($P < 0.05$) according to Tukey test

RESULTS AND CONCLUSIONS

- Soil contamination and the addition of the organic mater amendments (especially manure) influenced negatively mycorrhizal colonisation in *S. nigrum*
- Plants biomass was negatively influenced by the Zn contamination in the soil
- AMF colonisation did not influence the biomass yield of *S. nigrum*
- The addition of manure promoted the increase of the biomass of all plant sections; compost addition only induced enhanced leaf biomass
- Inoculation with *Glomus claroideum* or *Glomus intraradices* enhanced the uptake and accumulation of Zn by *S. nigrum*
- The establishment of *S. nigrum* in combination with OM amendments provided a reduction in the quantity of Zn leached of ca. 70 to 80% → reduction of metal dissemination
- The addition of manure increased the stabilisation abilities of the plant by reducing zinc accumulation in *Solanum nigrum*, up to eighty percent; the addition of compost resulted in reductions in zinc accumulation of up to forty eight percent

The use of *Solanum nigrum* in the stabilisation of Zn contaminated soil, amended with manure, can be seen as a feasible remediation scenario, especially for soils with high zinc contents, as it will be able to stabilise the soil with a green cover and reduce the amount of metal percolated and disseminated via animal consumption. Additionally the plant will be accumulating a small part of the metal in its tissues and can act like a go-between step until other solutions can be developed.

ACKNOWLEDGEMENTS

The authors wish to thank Câmara Municipal de Estarreja for granting access to the site and Miroslav Vosátka for providing the AMF isolates used in the work. This work was supported by Fundação para a Ciência e a Tecnologia, research grants of Ana Marques (SFRH/BPD/34585/2007) and Rui Oliveira (SFRH/BPD/23749/2005). The work was funded by Project MICOMETA - POCI/AMB/60131/2004 (Fundação para a Ciência e Tecnologia).