Zinc accumulation and histolocalisation in *Solanum nigrum* grown in contaminated soil: effect of arbuscular mycorrhizal fungi

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Abstract

Zn tissue accumulation in *Solanum nigrum* grown in a non-contaminated and a naturally contaminated Zn matrix and the effect of inoculation with different arbuscular mycorrhizal fungi (AMF) on metal uptake were assessed. The Zn level in the soil used in this study - 426 mg Zn/ kg dry soil - is higher than what is set in the Portuguese legislation (EC Directive 86/278/CEE from June 12th). *S. nigrum* plants grown in the contaminated soil accumulated up to 1622 mg kg^{-1} of Zn in the roots, 411 mg kg^{-1} in the stems and 253 mg kg^{-1} in the leaves, with no visual toxicity signs. The levels registered for the roots are considered as phytotoxic for plants – 500 to 1500 mg kg^{-1}, according to Chaney (1989) – but all the tissues showed Zn levels above what is considered as normal levels in plant tissues - 10 to 100 mg kg^{-1}, according to Frisberg et al. (1996), independently of the inoculation with AMF. The presence of AMF did not influence the biomass of *S. nigrum* individuals, but both *Glomus claroideum* and *Glomus intraradices* enhanced the uptake and accumulation of Zn by *S. nigrum*. The inoculation with *G. claroideum* induced an increase of 58, 44 and 120% in the Zn accumulation levels for the roots, stems and leaves, respectively, when comparing to the non-inoculated plants. When inoculated with *G. intraradices,* the increase in the accumulation levels was of 54, 39 and 122% for roots, stems and leaves, respectively.

The knowledge of the metal distribution in cell compartments is important for understanding the tolerance mechanisms in plant species. In the present study, autometallography was performed on root samples of all treatments as a way of determining the location of the accumulated Zn in root tissues of *S. nigrum*. Electron-dense deposits of the metal were found in the appoplast (cell walls and intercellular spaces) and inside the cell, in the vacuoles. According to Memon et al. (2001), Zn location at the cell wall level is one of the resistance mechanisms of tolerant plants, as it allows avoiding the Zn in the most sensitive areas, where the metabolic activities take place. Compartmentalisation of the metal in the vacuole also avoids these sensitive areas to be affected. The accumulation of Zn in the cell walls and intercellular spaces was observed in plants for all the AMF treatments, as for the non-inoculated control.

These findings indicate that *S. nigrum* inoculated with selected heavy metal tolerant AMF presents extracting and accumulating capacities, constituting a potentially suitable remediation method for Zn polluted soils.

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References

Chaney, R.L., 1989. Toxic element accumulation in soils and crops: protecting soil fertility and agricultural food-chains, in: Bar-Yosef, B., Barrow, N.J., Goldshmid, J. (Eds.), Inorganic Contaminants in the Vadose Zone. Springer-Verlag, Berlin, pp. 140-158.

Frisberg, L., Nordberg, G.F., Kessler, E., Vouk., V.B., 1996. Handbook of the toxicology of metals, Vols I ,II, second ed., Elsevier Science Publishers, Amsterdan.

Memon, A.R., Aktoprakligil, D., Ozdemir, A., Vertii, A., 2001. Heavy metal accumulation and detoxification mechanisms in plants. Turkish Journal of Botany 25, 111-122