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HOW DO LOW DOSES OF DFOB AND EDTA AFFECT THE PHYTOEXTRACTION OF Cd, Cu, Pb AND Zn BY HELIANTHUS ANNUUS?

Jean-Yves Cornu1,2, Clément Dépenet1,2, Armelle Braud3, Thierry Lebeau3
1INRA, UMR ISPA 1391, CS 20032, F-33882 Villeneuve d’Ornon, France
2Univ. Bordeaux, UMR ISPA 1391, CS 40201, F-33175 Gradignan, France
3Univ. Nantes, UMR LPGN 6112, BP 92208, 44322 Nantes cedex 3, France
Corresponding author email: lycornu@bordeaux.inra.fr

ABSTRACT

Phytoextraction is the only way for the in situ cleaning-up of metal-contaminated soils. This technology is environmental friendly and cost-effective compared to physico-chemical clean-up process but its effectiveness must be improved to cope with the requirements of planners and users. The main weakness of phytoextraction is the long cleaning-up duration (Baker et al. 2000) primarily caused by the low phytoavailability of metals in soil. Inoculation of siderophore-producing bacteria (SPB) has been recently proposed as a strategy to optimize metal phytoextraction (Rajkumar et al. 2010). The localized and continuous production of siderophore in the close vicinity of plant roots, where most of the SPB are established, would help in promoting metal phytoextraction with minimizing the risk of metal leaching. However, there is a need to dissect how siderophores interact with metals at the soil-root interface to better assess the potential of coupling phytoextraction with the inoculation of SPB.

The present study focuses on desferrioxamine B (DFOB), the main siderophore produced by the actinobacteria Streptomyces pilosus. DFOB is characterized by a high selectivity for Fe(III) (10^{11} M^{-1}) but also by a good affinity for divalent metals including Cd(II) (10^{7.9} M^{-1}), Cu(II) (10^{14.1} M^{-1}) and Zn(II) (10^{11.1} M^{-1}). The purpose of this work was to compare the efficiency of a low dose of DFOB vs. EDTA on the phytoextraction of Cd, Cu, Pb and Zn by sunflower. The main goal was to dissect the impact both chelators have on (1) the metals mobilisation from the solid phase, (2) their speciation in soil solution, (3) their uptake by plant roots and (4) their translocation from roots to shoots, for two cultivars of sunflower grown on an agricultural poly-contaminated soil.

Two cultivars of sunflower (ES RICA, KAPPLAN) with contrasted pattern of metal repartition (Laporte et al., 2014) were grown for 28 days on a calcareous soil (pH 7.3) contaminated in Cu, Cd, Pb and Zn (334, 5.2, 1191 and 561 mg kg^{-1} soil, respectively). Four days after transplanting, DFOB was supplied at the concentration of 200 μmol kg^{-1} soil to mimic bacterial production. The same procedure was performed for EDTA. Soil solution was extracted every week (on days 9, 16 and 23) using Rhizon soil moisture samplers. At harvest, xylem sap was collected on every plant by the “root pressure” method. Then, plants were divided into roots and shoots, and all plant tissues were freeze-dried, weighed, milled and digested in a mix HNO_3: H_2O_2. The concentrations of metals (Fe, Cu, Cd, Pb, Zn) in soil solution, xylem sap and plant tissues were assayed by ICP-MS. Investigations are in progress to quantify in soil solution (i) the concentrations of DFOB and EDTA using the Fe-CAS complex, and (ii) the labile fraction of metals by anodic stripping voltammetry.

The results will provide new insights on the mechanisms by which DFOB alters the soil-plant transfer of metals and, thus, on the efficiency of coupling phytoextraction with the inoculation of siderophore-producing-bacteria.

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