Using beneficial bacteria to facilitate phytoremediation of metal polluted soils under drought stress

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Beneficial bacteria possessing plant growth promoting (PGP) activities and abiotic stress resistance have great potential to improve phytoremediation process. However, it is not clear how plants grown on metal polluted soils respond to drought stress (DS) and bacterial inoculation in combination. The aim of this study was to investigate the effects of drought resistant rhizobacteria on plant growth and metal uptake by *Brassica oxyrrhina* under well water and DS conditions. Among a collection of drought resistant bacterial strains isolated from the rhizosphere of *Phleum phleoides* and *Trifolium repens* grown on serpentine soils, two bacterial strains TR1 and Ph3R3 were selected based on their ability to stimulate seedling growth in modified roll towel assay. By 16S rRNA gene sequencing analysis, TR1 and Ph3R3 were identified as *Pseudomonas libanensis* and *P. reactans*, respectively. Further assessment on PGP parameters revealed their intrinsic ability to produce indole-3-acetic acid, siderophore and 1-aminocyclopropane-1-carboxylate deaminase. In addition, these two strains exhibited high resistance to heavy metals (Ni, Cu, Cr, Pb and Zn), various antibiotics, salinity and extreme temperature. In the microcosm experiment, inoculation of TR1 and Ph3R3 significantly increased plant growth, leaf relative water content, pigment content, whereas decreased concentrations of proline and malondialdehyde in plant leaves under metal in the absence and presence of DS. The underlying mechanism of plant growth promotion under metal or/and DS could be attributed to the abilities of selected strains to compatibly colonize plant root system, to enhance abiotic stress tolerance and to produce various PGP metabolites, by which help plant inhibit stress ethylene production as well as improve mineral and water uptake. Regardless of water conditions in soils, inoculation of TR1 and Ph3R3 greatly improved the organ metal (Cu and Zn) concentrations as well as translocation factor and bioconcentration factor of metals compared with non-inoculated plants. It is concluded that the successful colonization and metabolic activities of abiotic stress (drought and metal) resistant *P. libanensis* TR1 and *P. reactans* Ph3R3 represent positive effects on plant development and phytoremediation of metal contaminated soils under DS.

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