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Genotypic variability of germanium (Ge) and rare earth element (REE) accumulation in Phalaris arundinacea L. (red canary grass)

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Phytomining comprises a promising chance to improve the supply of Ge and REEs as raw materials. Efficiency of the phytoextraction process depends on root-soil-interactions affecting the availability of the elements in the rhizosphere. Until today, data on effects of rhizosphere processes on the availability of these target elements from soils to plants are very scarce. The aim of the present study was to evaluate the variability in the accumulation of Ge and REEs in different genotypes of Phalaris arundinacea in order to identify below-ground functional root traits affecting the availability of the target compounds. In a three-year field experiment 20 genotypes of Phalaris arundinacea were cultivated on four substrates with similar element concentrations but differing organic matter contents (SOM 5.5 – 9%) and pH-values (pH 6.6 – 8). On each of the substrates each genotype was cultivated on plots (4 m2 each) with two replications. Subsequently, two genotypes with highest and lowest concentrations were selected and cultivated in a greenhouse experiment on soil and sand in order to elucidate genotypic variability in the uptake-efficiency among genotypes and mobilization of the elements in the rhizosphere. For the experimental setup we used pots filled with either 1.8 kg of quartz sand or soil (pH(H_2O) = 6.2; SOM = 7.6%, Ge (total) 1.8 μg g-1; La 26.6 μg g-1, Nd 23.9 μg g-1, Gd 4. μg g-1, Er 2.5 μg g-1). Over a growth-period of four weeks all soil-grown plants received 100 ml of nutrient solutions without elements. Sand-cultured plants received 10 μmol l-1 Ge and REEs 24 h before harvest or nutrient solutions as a reference. Element concentrations in all plant samples were analyzed by ICP-MS.
Considering all substrates, we found a genotypic variation in the accumulation of Ge and REEs in shoots, with average concentrations for Ge ranging from 0.03 – 0.95 μg g-1 and REEs (sums over all 16 elements) ranging from 0.02 – 5.7 μg g-1. Slightly acidic soil conditions (B2: pH 6.6.; SOM: 8%) and organic fertilizer treatment significantly increased the uptake of Ge and REEs in some genotypes, while others showed no response to changes in SOM and pH, most probably as a result of phenotypic plasticity. As a result of the greenhouse experiment we found that both, differences in the uptake efficiency of the genotypes as well as different efficiencies in the mobilization of the elements in the rhizosphere of soil-grown genotypes affects the accumulation of Ge and REEs in the shoot biomass (concentrations and amount of elements per unit area).
Ongoing studies aim to identify the processes involved and cross-breed those genotypes with the highest accumulation of target compounds in order to establish a new strain of RGG most suitable for phytomining of these target compounds.
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