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The potential of beech seedlings to adapt to low P availability in soil – plant versus microbial effects on P mobilising potential in the rhizosphere

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The objective of our work was to investigate to what extent tree seedlings (Fagus sylvatica) are able to adapt the process of P mobilisation in the rhizosphere according to P speciation in the soil. Such mobilisation activity can include root exudation of P mobilising compounds or stimulation of specific P mobilising soil microbes. We hypothesized that Fagus sylvatica seedlings can adapt their own activity based on their P nutritional status and genetic memory of how to react under a given nutritional situation.
To test the hypothesis, we set up a cross-growth experiment with beech of different provenances growing in soil from their own provenance site and in soil differing in P availability. Experiments were performed as a greenhouse experiment, with temperature control and natural light, during one vegetation period in rhizoboxes . We used two acidic forest soils, contrasting in P availability, collected at field sites of the German research priority program "Ecosystem Nutrition". Juvenile trees were collected along with the soils at the sites and planted respectively.
The occurrence of P mobilising compounds and available P in the rhizosphere and in bulk soil were measured during the active growth season of the plants. In particular, we assessed phosphatase activity, (measured with zymography and plate enzymatic assay at pH 4,6.5, and 11) carboxylates and phosphate (measured by application of ion exchange membranes to specific soil micro zones, and by microdialysis), and pH (mapping with optodes). Plant P nutrition status was assessed by total P, N/P, phosphatase activity, and metabolic (TCA extractable) P in the leaves.
The P-nutritional status of the beech provenances differed markedly independent from the P status of the soil where they were actually grown during experiment. In particular, the juvenile trees from the site rich in mineral P were sufficient in P, while those from the P-poor site with mostly organic P, were deficient. Enzymatic activity at the rhizoplane was mostly determined by the soil and was affected only to a small degree by plant provenance. On the other hand, plant provenance appeared to affect the occurrence of oxalate in the rhizosphere. The observed pH gradients near the root reflect the production of nitrate in the soil and the plant nitrate uptake.
These results suggest, that the potential to hydrolyse organic P in the rhizosphere is mainly governed by the existing soil microbial community, while the plant itself actively influence the mobilisation of inorganic P by root exudation of carboxylates or possibly by stimulating the carboxylate exudation by specific microorganisms.