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Competition between roots and microorganisms for phosphorus: A novel 33P labeling approach

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While organic N mineralization exhibits clear seasonal uptake dynamics, knowledge about seasonal variation in microbial P uptake and mineralization is scarce. We hypothesize that the dynamics of P uptake and mineralization by microorganisms in temperate forest soils exhibit a seasonality anti-cyclic to plant P uptake. Therefore, the ratio of microbial P to labile P increases by the transition from acquiring ecosystems (in spring) to recycling ones (in fall).

To investigate this, intact soil-plant mesocosms containing Ah horizon with 1 year old F. sylvatica were removed from the P-rich field site Bad Brueckenau and the P-depleted field site Luess in Germany. During incubation under controlled conditions, seasonal pulse labeling by 33P-orthophosphate was performed at 5 time points over the course of one year. 33P recovery in microbial compounds of organic and mineral soil horizons was determined 7 and 30 days after the labeling. This procedure will account for temporal changes in P allocation and also considers the rather slow P transport from the mycorrhiza into the plants and other microorganisms. For the first time we analyzed the 33P incorporation into total PLFA and consequently provide a new technique for the analysis of P uptake by microorganisms, which has clear advantages compared to P quantification after chloroform fumigation. Polar lipids are hereby extracted with a Frostegård-modified Bligh-and-Dyer buffer, i.e. a single phase mixture of chloroform, methanol and citrate buffer (0.8:1:2, v:v:v). Phospholipids (PLFA) are isolated and purified by solid phase extraction via a silica gel column chromatography. Subsequently, PLFA are hydrolyzed and the resulting fatty acids derivatized by methylation. The fatty acid methyl esters were extracted with n-hexane and measured by GC/MS to investigate the composition of the microbial community. The remaining extract, containing head groups, phosphate units and glycerol backbones, was used to determine 33P activity and recovery in the microbial membrane lipids with a multi-purpose scintillation counter.

This approach offers the unique possibility to quantify P fluxes through the microbial network. For the first time, P cycling can be linked to changes in microbial community structure and activity in soils in situ.