Geophysical Research Abstracts
Vol. 19, EGU2017-759-1, 2017
EGU General Assembly 2017

Spatial P heterogeneity in forest soil: Influence on microbial P uptake and community structure

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Other than nitrogen, phosphorus (P) is the most important growth limiting nutrient in soils. Yet, little information is available concerning the spatial heterogeneity of P content in forest soils. More so, the effects of a homogeneous vs. heterogeneous soil P distribution on microbial P acquisition and community structure have yet to be determined. Thus, a rhizotron experiment based on a P-deficient forest soil was conducted to investigate competitive P uptake strategies of microbes. F. sylvatica-bearing rhizotrons were labeled with Fe33PO4, a relatively immobile P source native to the study soil. Homogeneous and heterogeneous P patterns were created to study the effects of spatial P heterogeneity on plant and microbial P acquisition. P mobilization by microorganisms was tracked by an improved 33P-PLFA method, linking 33P incorporation in microbes with changes in microbial community structure in soils in situ.

The microbial P uptake was enhanced in rhizotrons with high P availability and in those with a patchy P distribution. Characteristic PLFAs indicate a congregation of beech-associated ectomycorrhizal fungi in P-rich patches. These ectomycorrhizal fungi are likely to strongly increase P mobilization from the used Fe33PO4 in high P habitats. In contrast, habitats with low P availability require a more complex microbial community structure without a dominant group to mobilize this inaccessible P source. Therefore, hotspots of P are likely to promote the efforts of fungal hyphae for P mobilization – an effect which decreases with lower P content. Additionally, gram positive and negative bacteria exhibit a vastly higher P uptake under increasingly patchy P distributions. However, they form a smaller portion of the microbial community than in homogeneously P enriched rhizotrons, suggesting that filamentous organisms benefit from the patchy P distribution. Thus, only a heterogeneous P distribution promotes P acquisition of forest microbial communities from mineral P sources with low bioavailability.

These novel insights into the effects of spatial P distributions on forest soil community dynamics will hopefully shed further light on microbial P cycling, thereby helping to tackle the impending global P crisis.