Geophysical Research Abstracts
Vol. 20, EGU2018-3899, 2018
EGU General Assembly 2018

Spatio-temporal patterns of enzyme activities after manure application

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Manure is an important source of nutrients for plants and stimulates a wide range of enzyme-mediated microbial processes. Such stimulation, however, is dependent on manure distribution and the duration of its decomposition in soil. The objective of this study was to investigate the spatial and temporal patterns of enzyme activities as affected by manure application strategies: 1) Localized manure: manure application as a layer in the upper soil; 2) Homogenized manure: mixing manure with whole soil and 3) No manure: a control without manure application. Yak manure and silty soil from the Tibetan Plateau were mixed and incubated in rhizoboxes at 20 °C for 45 days. Tibetan barley was planted. Soil zymography was used to visualize the two-dimensional distribution of the activities of three enzymes, which are involved in the cycling of, respectively, C (β-glucosidase), N (N-acetylglucosaminidase) and P (phosphomonoesterase). Dynamics were observed with measurements on days 5, 25 and 45 after manure addition. The manure detritusphere elevated enzyme activities relative to the control (with only rhizosphere effect of barley), but this stimulation lasted less than 45 days. Enzyme activities in the manure-induced hotspots of bulk soil were higher than on the rhizoplane, indicating that microbial activities in the detritusphere are more strongly stimulated than on the root surface. Homogenized manure led to 3-29% higher enzyme activities than localized manure, while localized manure induced 3.1 times more shoot biomass and 6.7 times more root biomass than homogenized manure. Thus, microorganisms were successful competitors for nutrients from homogeneous manure application, while plants benefited more from localized manure application. We conclude that spatial niche differentiation between roots and microorganisms decreases their competition and simultaneously increases microbial activities and plant performance.