Geophysical Research Abstracts
Vol. 16, EGU2014-8222, 2014
EGU General Assembly 2014

Plant species richness increases phosphatase activities in an experimental grassland

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Plant species richness has been shown to increase aboveground nutrient uptake requiring the mobilization of soil nutrient pools. For phosphorus (P) the underlying mechanisms for increased P release in soil under highly diverse grassland mixtures remain obscure because aboveground P storage and concentrations of inorganic and organic P in soil solution and differently reactive soil P pools are unrelated (Oelmann et al. 2011). The need of plants and soil microorganisms for P can increase the exudation of enzymes hydrolyzing organically bound P (phosphatases) which might represent an important release mechanism of inorganic P in a competitive environment such as highly diverse grassland mixtures. Our objectives were to test the effects of i) plant functional groups (legumes, grasses, non-leguminous tall and small herbs), and of (ii) plant species richness on microbial P (P_{mic}) and phosphatase activities in soil. In autumn 2013, we measured P_{mic} and alkaline phosphomonoesterase and phosphodiesterase activities in soil of 80 grassland mixtures comprising different community compositions and species richness (1, 2, 4, 8, 16, 60) in the Jena Experiment.

In general, P_{mic} and enzyme activities were correlated (r = 0.59 and 0.46 for phosphomonoesterase and phosphodiesterase activities, respectively; $p < 0.001$) illustrating the important role of microorganisms in the transformation of organic to inorganic P in soil. Similarly, standing root biomass was related to enzyme activities (r = 0.32 and 0.34 for phosphomonoesterase and phosphodiesterase activities; $p < 0.005$). Therefore, roots seem to contribute to enzyme activity via exudation of extracellular enzymes. Enzyme activities depended on soil moisture (ANCOVA, explained sum of squares 42% and 24% for phosphodiesterase and phosphomonoesterase activity, respectively, $p < 0.001$). Plant functional groups had no effect on P_{mic}, alkaline phosphomonoesterase or phosphodiesterase activities in soil (ANOVA, $p > 0.05$). Plant species richness explained a considerable part of the variance in P_{mic} and enzyme activities (25, 43, and 42% for P_{mic}, phosphomonoesterase and phosphodiesterase activity, respectively). One reason could be higher accumulation of above- and belowground plant litter (Steinbeiss et al. 2008, Fornara and Tilman 2009) in soil and thus, of substrate for enzyme activity under highly diverse grassland mixtures. However, single regressions showed that organic P (Po) concentrations in different fractions ($NaHCO_3$-Po, NaOH-Po, HCl-Po) explained not more than 6% of the variation in enzyme activities. Therefore, substrate availability does not constrain enzyme activity. Because of the relationships between enzyme activities and P_{mic} / root standing biomass we infer that exudation of enzymes by microbes and roots is driven by the competition for P resulting in increased hydrolysis of organically bond P and subsequent uptake by plants and microbes in highly diverse mixtures.

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