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Use of stoichiometry to predict the abundance and functioning of root symbioses

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Plants form nutritional symbioses with fungi and bacteria and the importance of these partnerships varies with the mineral fertility of soil. There is strong evidence that plants acclimate and adapt to their local soil conditions through root symbioses; nitrogen limitation is ameliorated by symbiosis with diazotrophic prokaryotes and mycorrhizas ameliorate phosphorus limitation. Corollaries of ecological stoichiometry may be useful for predicting the abundance and functioning of mycorrhizas and N-fixation symbioses. A series of field experiments show that arbuscular mycorrhizal (AM) symbioses in grasslands in North America and in the African Serengeti are most beneficial to plant nutrition when plants are phosphorus limited and have sufficient nitrogen and carbon. A reciprocal inoculation experiment shows that locally adapted communities of AM fungi, associated soil organisms and plants arise such that mutualistic benefits are maximized; both AM fungi and plants grew best in their "home" soil-symbiont combination compared to "away" soil-symbiont combinations. Plants in their home combination acquired more limiting resource (either phosphorus or nitrogen) and consequently grew larger; similarly, AM fungi in their home combination formed more arbuscules and extraradical hyphae. Genetic analysis of the AM fungi inside plant roots indicate that these results correspond to variation in the community composition of AM fungi and also to variation in the symbiotic performance of local isolates of one particular species of AM fungus. The next step is to conduct landscape scale studies of root symbioses to test the hypothesis that plants cultivate microbial communities in and around their roots such that the species and ecotypes of microorganisms within these communities is customized for optimal nutrient acquisition under site-specific environmental conditions. If locally adapted communities of root and rhizosphere organisms are common, then plants may be optimizing their foraging by fostering microbial partnerships which compensate for unfavorable resource stoichiometry. This finding would suggest that the communities of microorganisms associated with plant roots are somewhat analogous to the communities of microorganisms that animals cultivate in their gut.