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Zooming in to test theoretical assumptions in soil ecological stoichiometry – C:N:P ratios, homeostasis and demands in saprotrophic fungi

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Ecological stoichiometry represents a powerful tool to understand and predict biochemical processes at different scales. Differences among soil, plant and microbial element ratios are used to predict nutrient limitations, element cycling and ultimately the fate of carbon (C) in soils. These seminal applications are based on fundamental assumptions about soil microorganisms, which have rarely been tested at the level of individual microbial species. This is especially the case for saprotrophic fungi, which substantially contribute to nutrient recycling in soils. Thus, we tested hypotheses derived from those theoretical assumptions that (1) unlike autotrophs soil fungi show strong homeostasis especially regarding C:N ratios and (2) nitrogen (N) and phosphorus (P) demands in different environments can be predicted from organismic C:N:P ratios. We used a well characterized fungal collection of 16 species isolated from a temperate grassland. Fungi were exposed to an experimental N and P gradient in defined inorganic growth media, and their molar C:N:P ratios were determined as well as a range of fungal traits. Additionally, fungal C:N:P ratios were analyzed in more complex cellulose and soil-extract medium (SEA) and related to responses of glucose, cellulose, N and P additions, respectively. Interestingly, the fungal C:nutrient ratio is extremely plastic and may reach unexpectedly high values, especially in low nutrient media. By contrast, N:P ratios are more homeostatic and phylogenetically conserved. In growth environments with easily available glucose as a C source, C:N and C:P ratios represent good predictors of N and P demands, fungal growth rates and activity. However, in case of more complex C sources in natural environments, high fungal C:nutrient ratios rather indicate C demands, supporting the general assumptions of predominant C limitation of microbes in soil. These data suggest that the special physiology of mycelial growth causes very distinct stoichiometric patterns in fungi, characterized by highly efficient re-translocation of N and P within the mycelium, in contrast to high demands for C as a structural component.