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Intracellular storage: implications for microbial growth, element cycling and soil ecology

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Storage of resources like carbon and energy plays a central role in the lives of all organisms and alters their ecological interactions. Some soil-derived bacteria can accumulate intracellular carbon in the form of polyhydroxybutyrate (PHB) to as much as 50% of their dry biomass, while the accumulation of triacylglycerides (TAG) is well known in eukaryotes like fungi. Soil is an extremely variable habitat, featuring seasonal and hydrological fluctuations as well as intermittent and unpredictable inputs from roots, plant litter, and mesofauna. Storage is especially important for growth and survival in variable environments like soil, yet has been largely neglected in experimental and theoretical soil ecology.

This review briefly introduces the diversity of bacterial and fungal storage compounds, including PHB, TAG, glycogen, trehalose, and polyphosphate. Principles of storage from general ecology are then reviewed, to determine how these can apply to soil microbial communities. This shows that different modes of storage are possible, affecting patterns of resource intake, reproduction and seasonal dynamics. An important general conclusion is that storage profoundly affects survival and growth strategies in the context of variable and unpredictable environments. It allows an organism to dynamically modulate its stoichiometry with respect to its environment; and environmental variability and stoichiometry can, in turn, favor or disfavor storage. This has implications for the interpretation of element flows and ecosystem stoichiometry. A systematic review of the existing evidence from soil and the broader observational, experimental and theoretical microbiology literature supports the relevance of these principles, and shows that storage compounds have fundamental consequences for element cycles, experimental design, and how we conceptualize microbial life histories in soil.