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Seasonal dynamics of soil microbial respiration, growth, biomass, and carbon use efficiency

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Soil microbial growth, respiration and carbon use efficiency (CUE) are essential parameters to understand, describe and model the soil carbon cycle. While seasonal dynamics of microbial respiration are well studied, little is known about how microbial growth and CUE change over the course of a year, especially outside the plant growing season. In this study we measured soil microbial respiration, growth and biomass in an agricultural field and a deciduous forest 16 times over the course of two years. We sampled plots, at which harvest residues or leaf litter were either incorporated or removed. We observed strong seasonal variations of microbial respiration, growth and biomass. All microbial parameters were significantly higher at the forest site, which contained 3.5% organic C compared to the agricultural site with 0.9% organic C. CUE also varied strongly but was overall significantly higher at the agricultural site ranging from 0.1 to 0.7 compared to the forest site where CUE ranged from 0.1 to 0.6. We found that microbial respiration and to a lesser extent microbial growth followed the seasonal dynamics of soil temperature. Microbial growth was further affected by plant or foliage presence. At low temperatures in winter, both microbial respiration and growth rates were lowest. Due to higher temperature sensitivity of microbial respiration, CUE showed the highest values in the coldest months. Microbial biomass C was also strongly increased in winter. Surprisingly, this winter peak was not connected to high microbial growth or an increase in DNA content. This suggests that microorganisms accumulated osmo- or cryoprotectants but did not divide. This microbial winter bloom and following decline, where C is released and can be stabilized, could constitute the main season for C sequestration in temperate soil systems. Highly variable CUE, and the fact that CUE is calculated from independently controlled microbial respiration and growth, ask for great caution when CUE is used to describe soil microbial physiology, soil C dynamics or C sequestration. Instead, microbial respiration, microbial growth and biomass should rather be investigated individually to better understand the soil C cycle.