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Microbial biomass as a significant source of soil organic matter

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Soil organic matter (SOM) plays an important role for soil fertility and in the global carbon cycle. SOM management should be based on knowledge about the chemical composition as well as the spatial distribution of SOM and its individual components in soils. Both parameters strongly depend on the direct precursors of SOM. In the past, microbial biomass has been neglected as a potential source of SOM, mainly because of its small pool size. Recent studies, however, show that a substantial portion of SOM is derived from microbial biomass residues. We therefore investigated the fate of microbial biomass residues in soils by means of incubation experiments with 13C-labelled microbial biomass. For our studies, we selected model organisms representing the three types of soil microorganisms and their characteristic cell wall structures: Escherichia coli (a Gram-negative bacterium), Bacillus subtilis (a Gram-positive bacterium) and Laccaria bicolor (an ectomycorrhizal fungus). We labelled the organisms by growing them on 13C glucose and incubated them in soil. During incubation, we followed the mineralisation of the labelled C, its incorporation into microbial biomass, and its transformation to non-living SOM. We found that 50-65% of the microbial biomass C remained in the soil during incubation. However, only a small part remained in the microbial biomass, the majority was transformed to SOM. In particular, proteins seemed to be rather stable in our experiments. In addition, we used scanning electron microscopy to identify microbial residues in soils and, for comparison, in artificial groundwater microcosms. Scanning electron micrographs showed a low number of intact cells, but mainly fragments of about 200-500 nm size. Similar fragments were found in artificial groundwater microcosms where the only possible origin was microbial biomass residues. Based on the results obtained, we provide a mechanistic model which explains how microbial biomass residues are formed and stabilized in soils. This model also explains a number of chemical and physical properties of SOM such as the abundance and stability of microbial biomolecules, the low C/N ratio and the water repellency of SOM.