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Long-term compost application drives fungal decomposition of crop residues, thereby reducing their potential for soil organic carbon accumulation

BINGZI ZHAO AND JIANLI LIU

Institute of Soil Science, Chinese Academy of Sciences

The input of crop residues is a key practice for maintaining soil organic carbon (SOC) stocks. However, the long-term fertilization history of soil may regulate the microbial utilization of fresh residues and the subsequent priming effect (PE). Using a 90-day incubation with ^{13}C-labeled maize residues, we investigated how 20 years of different fertilization regimes—compost (COM), mineral NPK, and unfertilized control (NF)—affect residue decomposition and native SOC mineralization. Residue addition induced a positive PE across all soils, predominantly within the first 15 days. While the long-term COM soil exhibited the highest cumulative residue-derived CO_2 emissions, it paradoxically induced the lowest priming of native SOC compared to NPK and NF soils. This resulted in the COM soil having the lowest net SOC increase from residue incorporation. Microbial community analysis via PLFAs revealed that fungi were the primary decomposers of residue-C, though their relative abundance was lowest in COM soil. Conversely, actinomycetes showed higher relative abundance and increased residue-C utilization over time in COM soil. Our findings suggest that high-fertility soils from long-term organic inputs enhance the metabolic activity of fungi, accelerating the mineralization of fresh residues into CO_2. This rapid turnover limits the retention of new carbon, thereby reducing the potential for SOC accumulation from crop residues.