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Soil and microbial biomass stoichiometry regulate soil organic carbon and nitrogen mineralization in rice-wheat rotation subjected to long-term fertilization

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Abstract

Purpose Soil microbial biomass (SMB), as the source and sink of soil nutrients, and its stoichiometry play a key role in soil organic carbon (SOC) and nitrogen (N) mineralization. The objective of this study was to investigate the responses of SOC and N mineralization to changes in microbial biomass and SOC, N, and phosphorus (P) stoichiometry resulted from long-term fertilization regimes.

Materials and methods Soil was sampled from a rice-wheat rotation system subjected to 37 years of nine fertilization treatments with different nutrient input amounts: control (CK), N alone, N combined with mineral phosphorus (NP), NP plus potassium (NPK), manure alone (M), and M combined with N (MN), NP (MNP), NPK (MNPK), and a higher rate of M with NPK (hMNPK). The sampled soil was incubated for the determination of SOC and N mineralization, C, N, and P stoichiometry of soil and SMB, and associated soil enzymes related to C and N cycling.

Results and discussion Relative to the CK and treatments with mineral fertilizers, treatments with manure (M, MN, MNP, MNPK, and hMNPK) significantly increased SOC and N mineralization by 48–78% and 54–97%, respectively. Microbial metabolic quotient (qCO_2) decreased by 32–55% in treatments with manure compared to the N and NP treatments, but showed no effect on the qCO_2 when compared to the NPK treatment. The leucine amino peptidase (LAP) enzyme showed significant positive correlation with SOC and N mineralization, and negatively related to the qCO_2. Significantly negative correlations were also observed between SOC and N mineralization and soil C:P and N:P ratio, as well as microbial biomass SMBC:SMBP and SMBN:SMBP stoichiometry, respectively. However, the availability of N and P had limited effects on the qCO_2 after reaching a certain value (0.69–0.72 mg CO_2-C g^{-1} MBC h^{-1}).

Conclusions Lower soil elemental (C:P and N:P) and microbial biomass stoichiometry (SMBC:SMBP and SMBN:SMBP) and increase of LAP resulted from combined application of manure and mineral fertilizers, accelerated SOC, and N mineralization. Mineral nutrient input with manure amendments could be an optimal strategy to meet the microbial stoichiometric demands and enhance nutrient availability for crops in agricultural ecosystems.

Keywords Stoichiometry · SOC mineralization · Nitrogen mineralization · Microbial biomass · Nutrient availability · Long-term fertilization

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