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Soil microbial biomass and extracellular enzymes regulate nitrogen mineralization in a wheat-maize cropping system after three decades of fertilization in a Chinese Ferrosol

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Abstract

Purpose Soil net nitrogen (N) mineralization is a vital process that impacts the global N cycling and regulates the N availability for plant development. The objectives of this study were to evaluate the response of N mineralization to long-term organic versus inorganic fertilization and to quantify the relationships between N mineralization and soil microbial characteristics in the ferrosol (red soil) of South China after 30 years of mineral and manure application in a wheat-maize cropping system.

Materials and methods Soil was sampled from a wheat-maize rotation system, consisting of five treatments. The treatments included (1) CK (no fertilizer), (2) PK (synthetic phosphorus and potassium fertilizer), (3) NK (synthetic nitrogen and K fertilizer), (4) N (synthetic N fertilizer), and (5) NPKM (synthetic NPK fertilizer and manure). The sampled soil was analyzed for physicochemical parameters and incubated for the determination of N mineralization, soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), and associated soil enzymes related to C and N cycling.

Results and discussion Results showed that NPKM increased soil organic carbon (SOC), available P (AP), total P (TP), and total nitrogen (TN) by 132%, 880%, 293%, and 76% respectively, over the control (CK). Among different treatments, soil microbial biomass nitrogen (SMBN) and carbon (SMBC) were highest under the NPKM treatment. N-cycling and P-cycling enzyme activities also showed significant differences among treatments. *N*-Acetyl-β-D-glucosaminidase (NAG), leucine-aminopeptidase (LAP), and acid phosphatase (AcP) activities were also highest under the NPKM treatment, at 650.36, 32.36, and 23.41 (mol g^{-1} h^{-1}), respectively. A linear increase was observed in the NO_3^--N and NH_4^+-N concentrations throughout the 90-day incubation period. NPKM showed a maximum N mineralization potential (N_o) and mineralization rate constant, k (NMR), at the end of the incubation period. A principal component analysis (PCA) interpreted the differences among fertilization and their effects on net N mineralization. A significant ($p \leq 0.05$) positive correlation was observed between SMBC ($R^2 = 0.87$), SMBN ($R^2 = 0.92$), enzyme activities, and the N_o. Structural equation modeling (SEM) revealed that SOC, TN, and TP directly affected mineralization, while SMBC and SMBN indirectly affected the net mineralization.

Conclusion Manure input increased the extracellular enzymes in soil, which accelerated the net N mineralization due to enhanced soil microbial activities. Consequently, long-term manure addition appears to be an optimal approach to meet the nutrient demands and to enhance the N availability in a wheat-maize cropping system.

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