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Soil nitrogen biogeochemical cycles in karst ecosystems, southwest China

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Soil nitrogen (N) status are crucial for ecosystem development and carbon sequestration. Although most terrestrial ecosystems are proposed to be limited by N, some tropical low-land forests have been found to be N saturated. Nevertheless, soil N status in the karst ecosystems of southwest China have not been well assessed so far. In the present study, N status in the karst ecosystems were evaluated based on several lines of evidence. Bulk N content increased rapidly along a post-agricultural succession sequence including cropland, grassland, shrubland, secondary forest and primary forest. Across the sequence, soil N accumulated with an average rate of 12.4 g N m-2 yr-1. Soil N stock recovered to the primary forest level in about 67 years following agricultural abandonment. Nitrate concentrations increased while ammonium concentrations decreased with years following agricultural abandonment. N release from bedrock weathering was likely a potential N source in addition to atmospheric N deposition and biological N fixation. Both gross N mineralization and nitrification (GN) rates decreased initially and then increased greatly following agricultural abandonment. The rate of dissimilatory nitrate reduction to ammonium (DNRA) was highest in the shrubland while lowest in the cropland and forest. Across the vegetation types, DNRA was lowest among the gross rates. Gross ammonium immobilization (GAI) tended to decrease while there was no clear variation pattern for gross nitrate immobilization during the post-agricultural succession. DNRA and nitrate assimilation combined only accounted for 22% to 57% of gross nitrification across the vegetation types. Due to the high nitrate production while low nitrate consumption, net nitrate production was found to vary following the pattern of gross nitrification and explained 69% of soil nitrate variance. Comparison of gross N transformations between a secondary karst forest and an adjacent non-karst forest showed that the gross rates of N mineralization, nitrification, dissimilatory nitrate reduction to ammonium (DNRA) and nitrate assimilation were significantly greater in the karst forest. Ammonium assimilation was comparable to gross N mineralization, so that ammonium could be efficiently conserved in the non-karst forest. Meanwhile, the produced nitrate was almost completely retained via DNRA and nitrate assimilation. This resulted in a negligible net nitrate production in the non-karst forest. In contrast, ammonium assimilation rate only accounted for half of gross N mineralization rate in the karst forest. DNRA and nitrate assimilation accounted for 21% and 51% of gross nitrification, respectively. Due to relatively low nitrate retention capacity, nitrate was accumulated in the karst forest. Our results indicate that 1) N would not be the limiting nutrient for secondary succession and ecological restoration in the karst region, 2) the decoupling of nitrate consumption with production results in the increase of soil nitrate level and hence nitrate leaching risk during post-agricultural succession in the karst region, and 3) the non-karst forest with red soil holds a very conservative N cycle, but the N cycle in the karst forest is leaky.