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Editorial: Carbon and nitrogen cycling in grassland ecosystems

Na Li[1], Qian Zhang[2], Sutie Xu[3], Daniela Businelli[4] and Qibing Wang[5]*

[1]Key Laboratory of Mollisols Agroecology, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Harbin, China, [2]Research Institute of Forestry, Chinese Academy of Forestry, Beijing, China, [3]Department of Agronomy, Horticulture and Plant Science, South Dakota State University, Brookings, SD, United States, [4]Department of Agricultural, Food and Environmental Sciences, University of Perugia, Perugia, Italy, [5]State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, China

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EDITED AND REVIEWED BY
Yuncong Li,
University of Florida, United States

*CORRESPONDENCE
Qibing Wang,
qwang@ibcas.ac.cn

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Editorial on the Research Topic
Carbon and nitrogen cycling in grassland ecosystems

Grasslands cover approximately 40% of the world's terrestrial surface and contain over one-third of above and belowground organic carbon (C) stocks (Bai and Cotrufo, 2022; Liu et al., 2023). Grasslands are of particular interest for C capture and sink, and their soil C sequestration has, therefore, been proposed as a plausible partial climate mitigation strategy (Tessema et al., 2020). The higher soil organic C (SOC) stocks in grasslands could be due to the perennial nature of grasslands, resulting in constant carbon inputs from aboveground vegetation and large amounts of organic carbon released into the subsoil via root exudates and decomposing deep roots (Zimmermann et al., 2012). Fisher et al. (1994) highlighted the potential for SOC sequestration by deep-rooted African grasses. Guo and Gifford (2002) estimated that the conversion of cropland to grassland increases SOC by approximately 19%. A meta-analysis reported by Conant et al. (2017) also found a 3%–5% increase, with rates ranging from 0.105 to over 1 $Mg\,C{\cdot}ha^{-1}{\cdot}yr^{-1}$ under different grassland management practices. Nevertheless, significant uncertainties exist in grassland C cycling, which determines soil C sequestration. For example, current estimates of soil C stocks in grasslands range from a significant source to a small sink. In addition, the significant differences among studies may be derived from the different approaches used in the estimates (Fang et al., 2010). These uncertainties and controversies reflect the lack of a comprehensive assessment of C cycling under different grassland management practices and climate regimes. Moreover, C and nitrogen (N) cyclings are highly coupled in terrestrial ecosystems, and N is an essential nutrient that determines the capacity of soils to sequester more C. Quantifying the C and N cycling processes and how C and N stocks respond to various management practices and environmental factors is essential to guide land-based mitigation strategies.

Information on C and N storage, stabilization, and estimation in grassland and arable ecosystems will help to better understand how soil C and N cycling processes have been affected by global change and management, and their underlying mechanisms. Five original research articles have been published on this Research Topic.

SOC is vital for sustainable agricultural production. Bursać et al. evaluated a transfer learning-based neural network model to improve classical machine learning estimation of SOC using geochemical and physical soil parameters. They found that the transfer learning approach provides better or at least equivalent output than the classical machine learning procedure. They proposed that the transfer learning methodology could be used to generate a pedotransfer function for target domains with described samples and unknown related pedotransfer function outputs if the described samples with known related pedotransfer function outputs from a different geographical or similar land class source domain are available.

The quality of soil organic matter (SOM) is the primary driver of nutrient cycling affecting the productivity of cropping systems. In a long-term experiment, Yadav et al. observed that the yields of rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), and maize (*Zea mays* L.) increased significantly under either organic or inorganic fertilizer treatments in Modipuram, India. Substitution of inorganic fertilizer N with organic sources to the 100% NPK showed comparable yields, while partial substitution of chemical fertilizers with either vermicompost and/or crop residues improved SOM quality and productivity regardless of cropping systems.

Crop rotation adaptations incorporating temporary grass-clover leys and organic amendments have been proposed to improve SOC sequestration and mitigate climate change in agricultural systems. In a long-term field experiment with different treatments, including crop rotation, grass-clover ley duration, and fertilizer sources, Zani et al. found that the soil C stocks were higher under the diversified organic rotation with a 3-year grass-clover ley period at both 0–30 cm and 30–60 cm soil depth, regardless of the fertilization source or sampling year. However, the organic rotation seemed to provide stable soil C stocks only in the subsoil layer. Compost fertilization, on the other hand, increased topsoil C stocks under both rotations and appeared stable. These results suggest that combining a diverse organic rotation with 3-year grass-clover ley and compost fertilization could be a way for agricultural systems to achieve stable soil C sequestration.

N is the primary production and decomposition driver in arid and semi-arid ecosystems. Across 43 shrubland sites spread over 3,000 km^2 in temperate desert grasslands of eastern Yanchi County, Ningxia, China, Zhao et al. found that total soil N showed strong spatial autocorrelation in 0–5 and 5–15 cm soils and moderate spatial autocorrelation in 15–40 cm soils. Soil physicochemical properties were more important than those of topography and plant biomass in determining the spatial distribution of total soil N. Soil moisture in the 0–20 cm soil explained 35% of the variation in the spatial pattern of total N in the 0–5 cm soil, while SOC in 15–40 cm soil explained 64% and 45% of the variations in the spatial pattern of total soil N in 5–15 cm and 15–40 cm soils, respectively, suggesting that soil moisture and SOC are the main drivers of spatial heterogeneity of total soil N in shrublands at the landscape scale in drylands.

Carbohydrate-active enzymes (CAZymes) are involved in the hydrolysis and biosynthesis of complex carbohydrates. Through a metagenomic approach, Zhang et al. observed a higher CAZyme abundance in severely degraded grasslands compared with the other three degradation levels (i.e., non-, lightly, and moderately degraded grasslands) in northern China, while glycoside hydrolase and glycosyltransferase were identified as the most abundant gene families. The Mantel test and variation partitioning suggested an interactive effect of degradation severity and soil depth on CAZyme gene composition. Structural equation modeling indicated that total soil carbon, microbial biomass carbon, and SOC were the three most crucial soil characteristics for CAZyme abundance, suggesting that degradation and soil carbon fractions interactively determine CAZyme gene composition. Moreover, both above and belowground factors associated with SOC play a central role in determining the abundance of CAZyme gene families.

We hope this Research Topic will provide some novel insights into C and N cycling, highlighting how these processes relate to global change and management practices and their underlying mechanisms in grassland ecosystems globally.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Bai, Y., and Cotrufo, M. F. (2022). Grassland soil carbon sequestration: Current understanding, challenges, and solutions. *Science* 377, 603–608. doi:10.1126/science.abo2380

Conant, R. T., Cerri, C. E. P., Osborne, B. B., and Paustian, K. (2017). Grassland management impacts on soil carbon stocks: A new synthesis. *Ecol. Appl.* 27, 662–668. doi:10.1002/eap.1473

Fang, J., Yang, Y., Ma, W., Mohammat, A., and Shen, H. (2010). Ecosystem carbon stocks and their changes in China's grasslands. *Sci. China- Life Sci.* 53, 757–765. doi:10.1007/s11427-010-4029-x

Fisher, M. J., Rao, I. M., Ayarza, M. A., Lascano, C. E., Sanz, J., Thomas, R. J., et al. (1994). Carbon storage by introduced deep-rooted grasses in the South American savannas. *Nature* 371, 236–238. doi:10.1038/371236a0

Guo, L., and Gifford, R. (2002). Soil carbon stocks and land use change: A meta-analysis. *Glob. Change Biol.* 8, 345–360. doi:10.1046/j.1354-1013.2002.00486.x

Liu, L., Sayer, E. J., Deng, M., Li, P., Liu, W., Wang, X., et al. (2023). The grassland carbon cycle: Mechanisms, responses to global changes, and potential contribution to carbon neutrality. *Fundam. Res.* 3, 209–218. doi:10.1016/j.fmre.2022.09.028

Tessema, B., Sommer, R., Piikki, K., Söderström, M., Namirembe, S., Notenbaert, A., et al. (2020). Potential for soil organic carbon sequestration in grasslands in east african countries: A review. *Grassl. Sci.* 66, 135–144. doi:10.1111/grs.12267

Zimmermann, J., Dauber, J., and Jones, M. B. (2012). Soil carbon sequestration during the establishment phase of Miscanthus× giganteus: A regional-scale study on commercial farms using ^{13}C natural abundance. *Glob. Change Biol. Bioenergy* 4, 453–461. doi:10.1111/j.1757-1707.2011.01117.x