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Editorial: The role of soil organic nitrogen in forest plant nutrition

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Editorial on the Research Topic
The role of soil organic nitrogen in forest plant nutrition

Nitrogen (N) availability often limits plant growth and primary productivity of forests (Högberg et al., 2017). Up to 95% of N pools in forest soils are present in organic forms, primarily as proteinaceous compounds and heterocyclic N molecules (Nicolás et al., 2019; Wang et al., 2020). Although, within the traditional framework, the utilization of organic N by plants has typically been considered dependent on microbial decomposition and mineralization (Schimel and Bennett, 2004), mounting evidence has shown that organic N can be directly used by plants, including not only small molecules such as amino acids and urine (Näsholm et al., 2009; Zhang et al., 2019), but also polyamines, peptides, and proteins (Warren, 2015; Adamczyk, 2021). Moreover, it has been recently revealed that plants can access organic N released from macromolecular structure of soil organic matter (SOM) via direct and indirect pathways (Wang et al., 2020; Maillard et al., 2023). These emerging findings provide a novel perspective on plant N nutrition, along with traditional notion of plant N availability through microbial N mineralization.

Despite the increasingly recognized importance of organic N in plant nutrition, our understanding of the underlying mechanisms facilitating plants to access soil organic N and the potential ecological implications remains limited. This is due partly because: (i) characterizing high-molecular-mass organic N in the field condition remains a methodological challenge; (ii) adding more complexity, soil N dynamics could be influenced by the spatial and temporal heterogeneity of multiple biotic and abiotic factors, including environmental conditions, climate change, plant and soil chemistry, and soil biota community. Recent efforts have been made to advance our knowledge in the delicate components and decomposition processes of SOM by incorporating state-of-art technologies such as isotopes, spectroscopy, and mass spectrometry into soil ecology (Keiluweit et al., 2012; Wang et al., 2020). This can also help better understand of the role and accessibility of organic N pools for plant nutrition.

This Research Topic aims to offer possibilities to collect novel research results or holistic viewpoints in the basic research field of soil organic N in forests. During the editorial process of this Research Topic, we have appreciated that significant progress has been recently

made regarding the plant mechanisms to access soil organic N and associated ecological implications (e.g., SOM stabilization), as well as driving factors controlling forest soil N dynamics which can inform valuable insight to evaluate the importance of organic N for plant N nutrition under different climate scenarios.

In N-limited forest ecosystems, ectomycorrhizal (ECM) fungi play a critical role in provisioning host trees with nutrition, not only acting functionally as root extensions, have also been demonstrated to hold the capacity to mobilize organic N from SOM (Nicolás et al., 2019). To advance the current understanding of the complex mechanisms underlying soil organic N acquisition by ECM fungi, Tunlid et al. developed an experimental approach that concurrently investigated the processes of decomposition alongside the changes in the structure and properties of SOM. Therein, the authors show that ECM fungi have significant capacities to assimilate organic N associated with SOM and mineral surfaces, with the decomposition mechanisms differing between ECM fungal species. The authors underline two pathways in ECM fungi that alter the adsorptive properties of SOM when mobilizing N, that is, extracellular modifications of SOM and secretion of mineral surface reactive metabolites. Considering that the decomposition of SOM happens when ECM fungi access organic N compounds embedded, the authors also highlight the necessity to extend the traditional framework for understanding organic N uptake from SOM by ECM fungi to an emerging flamework involving how ECM-induced decomposition impact SOM stabilization.

Multiple biotic and abiotic factors influence soil N dynamics which can change N utilization strategies of plants (Wang and Macko, 2011), and thus may determine the relative importance of organic N for plant N nutrition (Zhang et al., 2018). Sardar et al. provided a holistic review synthesizing potential factors affecting N dynamics in forest soils, including soil biota, tree species, root traits, soil properties, and climate and environmental conditions. Especially for some forest ecosystems (e.g., broadleaf and Moso bamboo forests) that are rather sensitive to environmental disturbance, even a small change in these factors can alter the overall soil N dynamics (Sardar et al.), consequently influencing the structure and functioning of forests. By conducting an *in-situ* warming experiment at the subarctic tree line, Meyer et al. showed that climate warming stimulated N mineralization and increased soil mineral N supply, which implies that the dependence of plants on direct supply of soil organic N might be decreased under future climate warming, even in strongly N-limited systems like the Arctic. Thus, the intensifying climate change adds more complexities and uncertainties in holistically understanding the role of soil organic N in forest plant nutrition and associated ecological consequences, with exciting opportunities remaining for future work regarding this topic.

The maintenance of forest productivity, structure, and function relies on efficient soil N supply and plant N acquisition. In this Research Topic, the underlying mechanisms facilitating plants to access soil organic N (e.g., the active plant-ECM fungal interactions) and key factors driving soil N dynamics in forests have been overviewed. The new knowledge gained from these studies would further our understanding of plant N nutrition in forests, but also increases the awareness of the complexity in depicting a clear picture of the role of soil organic N in forest plant N nutrition, especially under changing environments. Future studies should further push our frontiers in quantifying plant acquisition of soil organic N and the relative importance of different biotic and abiotic factors regulating soil N dynamics in forest ecosystems under the scenario of global change. As editorial team, we hope that this Research Topic will be helpful in contributing to formulating sustainable management strategies to adapt forests to global change.

Author contributions

ZZ wrote the first draft of this editorial. 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.

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References

Adamczyk, B. (2021). How do terrestrial plants access high molecular mass organic nitrogen, and why does it matter for soil organic matter stabilization? *Plant Soil* 465, 583–592. doi: 10.1007/s11104-021-05022-8

Högberg, P., Näsholm, T., Franklin, O., and Högberg, M. N. (2017). Tamm review: on the nature of the nitrogen limitation to plant growth in Fennoscandian boreal forests. *For. Ecol. Manag.* 403, 161–185. doi: 10.1016/j.foreco.2017.04.045

Keiluweit, M., Bougoure, J. J., Zeglin, L. H., Myrold, D. D., Weber, P. K., Pett-Ridge, J., et al. (2012). Nano-scale investigation of the association of microbial nitrogen residues with iron (hydr) oxides in a forest soil O-horizon. *Geochim. Cosmochim. Acta* 95, 213–226. doi: 10.1016/j.gca.2012.07.001

Maillard, F., Kohler, A., Morin, E., Hossann, C., Miyauchi, S., Ziegler-Devin, I., et al. (2023). Functional genomics gives new insights into the ectomycorrhizal degradation of chitin. *New Phytol.* 238, 845–858. doi: 10.1111/nph.18773

Näsholm, T., Kielland, K., and Ganeteg, U. (2009). Uptake of organic nitrogen by plants. *New Phytol.* 182, 31–48. doi: 10.1111/j.1469-8137.2008.02751.x

Nicolás, C., Martin-Bertelsen, T., Floudas, D., Bentzer, J., Smits, M., Johansson, T., et al. (2019). The soil organic matter decomposition mechanisms in ectomycorrhizal fungi are tuned for liberating soil organic nitrogen. *ISME J.* 13, 977–988. doi: 10.1038/s41396-018-0331-6

Schimel, J. P., and Bennett, J. (2004). Nitrogen mineralization: challenges of a changing paradigm. *Ecology* 85, 591–602. doi: 10.1890/03-8002

Wang, L., and Macko, S. A. (2011). Constrained preferences in nitrogen uptake across plant species and environments. *Plant Cell Environ.* 34, 525–534. doi: 10.1111/j.1365-3040.2010.02260.x

Wang, T., Tian, Z., Tunlid, A., and Persson, P. (2020). Nitrogen acquisition from mineral-associated proteins by an ectomycorrhizal fungus. *New Phytol.* 228, 697–711. doi: 10.1111/nph.16596

Warren, C. R. (2015). Wheat roots efflux a diverse array of organic N compounds and are highly proficient at their recapture. *Plant Soil* 397, 147–162. doi: 10.1007/s11104-015-2612-4

Zhang, Z., Li, N., Xiao, J., Zhao, C., Zou, T., Li, D., et al. (2018). Changes in plant nitrogen acquisition strategies during the restoration of spruce plantations on the eastern Tibetan Plateau, China. *Soil Biol. Biochem.* 119, 50–58. doi: 10.1016/j.soilbio.2018.01.002

Zhang, Z., Yuan, Y., Liu, Q., and Yin, H. (2019). Plant nitrogen acquisition from inorganic and organic sources via root and mycelia pathways in ectomycorrhizal alpine forests. *Soil Biol. Biochem.* 136, 107517. doi: 10.1016/j.soilbio.2019.06.013