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Functional diversity of soil invertebrates: a potential tool to explain N2O emission?

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Soil biota play a crucial role in the mineralization of nutrients from organic material. However, they can thereby increase emissions of the potent greenhouse gas nitrous oxide (N2O). Our current lack of understanding of the factors controlling N2O production and emission is impeding the development of effective mitigation strategies. It is the challenge to control N2O emissions from production systems without reducing crop yield, and diversity of soil fauna may play a key role. A high functional diversity of soil invertebrates is known to stimulate nitrogen mineralization and thereby plant growth, however, it is unknown whether a high functional diversity of soil invertebrates can concurrently diminish N2O emissions. We hypothesized that increased functional diversity of soil invertebrates reduces faunal-induced N2O emissions by facilitating more complete denitrification through (i) stimulating the activity of denitrifying microbes, and (ii) affecting the distribution of micro and macro pores, creating more anaerobic reaction sites. Using state-of-the-art X-ray tomography and next-generation sequencing, we studied effects of functional diversity on soil structural properties and the diversity of the microbial community (16S rRNA genes and 16S rRNA), and linked these to soil N2O emissions. In a 120-day study we found that the functional composition of the soil invertebrate community determined N2O emissions: earthworm activity was key to faunal-induced N2O emissions (a 32-fold increase after 120 days, $P<0.001$). No proof was found to explain faunal-induced N2O emissions through differences in stimulated microbial activity. On the other hand, soil structural properties (mean pore size, pore size distribution) were found to be radically altered by earthworm activity. We conclude that the presence of a few functional groups (ecosystem engineers) is more important than overall increased functional diversity in explaining faunal-affected N2O emissions.