SEL Research
长期施肥下原生生物对微生物残留物累积的影响

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Contrasting patterns of protists on accumulation of fungal and bacterial necromass in arable soil: Result of a long-term field experiment

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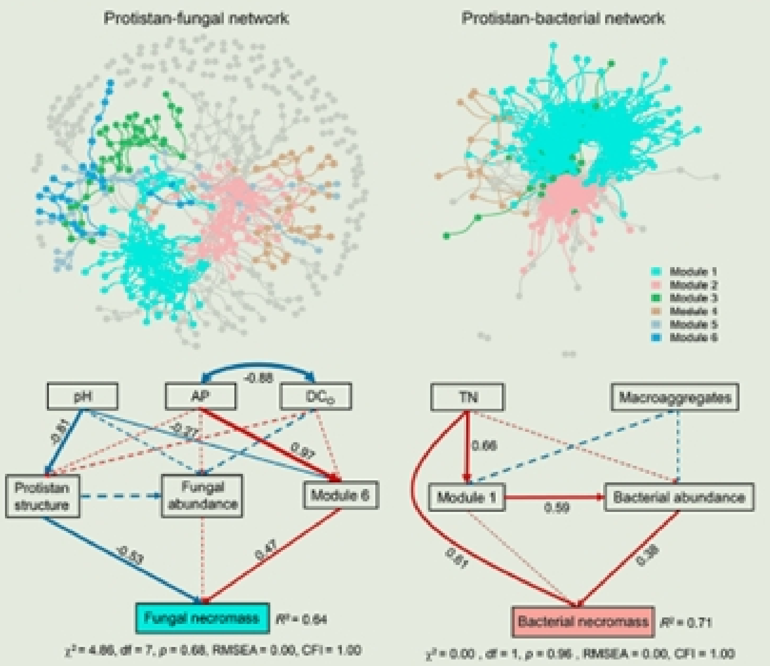
ABSTRACT

- The Ascomycota played a major role in fungal necromass formation in soil.
- Protists reduced fungal necromass while promoting bacterial ncromass accumulation.
- Soil total nitrogen substantially decided the persistence of bacterial necromass in soil.



Contrasting effects of protists on fungal and bacterial necromass

Microbial necromass plays a crucial role in soil organic carbon (SOC) formation. However, underlying abiotic and biotic factors on necromass accumulation remain poorly understood. Here, based on a 27-year field fertilization experiment in upland Ultisols, we investigated how changes in fungal and bacterial necromass relate to the abundance, diversity, community structure, and trophic co-occurrence networks of microbial communities, including fungi, bacteria, and protists. Fungal necromass contributed an average of 32.4% to SOC, a greater contribution than the 14.6% from bacterial necromass, regardless of fertilization regimes. Modularity analysis of the protistan-fungal network indicated that Ascomycota fungi were the primary contributors to fungal necromass accumulation in arable soil. The protistan community structure had a significantly negative effect on fungal necromass by directly decomposing fungal residues, rather than altering the fungal community structure. In contrast, soil total nitrogen positively influenced the persistence of bacterial necromass. Bacterial abundance was positively correlated with bacterial necromass. Protists increased bacterial abundance, thereby increasing bacterial necromass in the soil. Overall, protists regulated microbial necromass storage in arable soils either by decomposing fungal necromass or by increasing bacterial abundance.

Keywords microbial necromass, fungi, bacteria, protists, trophic interactions

本文以27年有机无机肥长期定位试验中不同肥力水平红壤为研究对象，研究了真菌和细菌残留物的变化与微生物群落（包括真菌、细菌和原生生物）的丰度、多样性、群落结构和多营养级互作网络之间的关系。研究发现，真菌残留物约占土壤有机碳的三分之一，高于细菌残体对有机碳的贡献。子囊菌具有生长速度快、碳利用效率高的特点，其在土壤真菌残体形成过程中发挥了重要作用。原生生物通过分解作用抑制真菌残留物的累积，而非影响真菌群落结构。相比之下，原生生物通过提高细菌丰度促进了细菌残留物的形成。土壤全氮对细菌残体的顽固性有很大影响，因为细菌残留物通常被认为是易利用的氮资源。总之，原生生物通过分解真菌残体或控制细菌数量

来改变微生物残体的积累。

微生物残留物在土壤有机碳（SOC）形成过程中起着至关重要的作用。然而，驱动微生物残留物累积的生物和非生物因素还不清楚，尤其是原生生物与真菌/细菌之间的相互作用如何影响真菌和细菌残留物的累积有待深入研究。本研究基于27年长期施肥定位试验，结合高通量测序与氨基糖分析，旨在阐明长期施肥下微生物残体对SOC累积的贡献特征，以及微生物属性特别是原生生物与真菌/细菌间的营养互作调控微生物残体形成的机制。结果表明：真菌残留物对SOC的平均贡献率为32.4%，高于细菌残留物的14.6%。对原生动物-真菌互作网络的模块化分析表明，子囊菌真菌是农田土壤中真菌残留物的主要贡献者。原生生物抑制真菌残留物的累积，其机制是直接分解真菌残留物，而非改变真菌群落结构。相比之下，细菌残留物与细菌丰度呈正相关关系。原生生物通过提高细菌数量促进了细菌残留物的形成。此外，土壤全氮对细菌残体的固存有很大影响。总体而言，原生生物通过分解真菌残留物或者改变细菌丰度来调节农田土壤中微生物残留物的累积。这项研究强调了原生生物在SOC形成过程中关键作用，对改进农田生态系统长期固碳潜力的预测具有重要意义，有助于在全球气候条件下加深对陆地碳循环过程的理解。

作者及团队介绍

苗运彩（第一作者），中国科学院南京土壤研究所特别研究助理，获得中国科学院南京分院院长特别奖、朱李月华优秀博士生奖。主要从事土壤碳循环及微生物机制等研究工作，主持了国家自然科学基金青年项目、江苏省自然科学基金青年项目、国家重点研发计划项目子课题和中国博士后科学基金面上项目。作为骨干参与国家重点研发计划项目、国家自然科学基金重点项目等。以第一作者在 Soil Biology and Biochemistry、mBio和Science of the Total Environment等期刊发表论文5篇。以合作作者在Global Change Biology、Agriculture, Ecosystems and Environment等期刊发表文章5篇。

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专题征稿

城市土壤生态与同一健康

Call for papers: Urban Soil Ecology and One Health

Urban landscapes are complex incubators for emerging public health threats, including the persistence and spread of zoonotic pathogens that jeopardize the integrated health of humans, animals, plants, and environments—a nexus addressed by the One Health framework. Within these ecosystems, soil biodiversity is a keystone component that underpins critical ecosystem functions, yet it persists as one of the least understood elements of urban ecosystems.

Aligned with the World Soil Day 2025 theme, "Healthy soils for healthy cities," this special issue calls for research to address this knowledge gap. We seek submissions that illuminate the distribution patterns and functional contributions of urban soil biota, particularly under pressures from human activity and climate change. We are also interested in studies exploring how harnessing urban soil biodiversity can lead to nature-based solutions for mitigating biodiversity loss, adapting to climate change, and reducing the urban burden of disease. We particularly encourage studies proposing frameworks for embedding soil biodiversity into urban governance and policy to directly enhance One Health outcomes.

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