EGU22-9338
https://doi.org/10.5194/egusphere-egu22-9338
EGU General Assembly 2022

Consequences of soil multitrophic biodiversity promoted by organic input management for ecosystem multifunctionality

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Soil biota, across multitrophic levels, regulates nutrient cycling and plant performance, and thereby play an important role in delivering multiple ecosystem functions. Soil nematodes occupy diverse positions in the soil food web, such as herbivores, bacterivores, fungivores, omnivores, and predators. Therefore, soil nematodes are usually considered as potential bio-indicators of soil quality or soil health under agricultural managements. However, there is a knowledge gap on how nematode multitrophic biodiversity (here the numbers of nematode trophic groups) affects soil multifunctionality.

This study combined field and laboratory experimental approaches to quantify and disentangle the aforementioned issue. First, we explored the impacts of compost application on nematode assemblages as well as multifunctionality based on a long-term field experiment. Results showed that compost application stimulated multitrophic biodiversity by the increase of microbivore and omnivore-predator abundance, while decreasing the herbivores. Besides, the increase of nematode multitrophic biodiversity was accompanied with the soil multifuctionality. Then a complete factorial design microcosm experiment was conducted with manipulating nematode trophic levels (microbivores, herbivores and omnivore-carnivores) to test the hypothesis that increasing multitrophic biodiversity will lead to higher soil multifuctionality as indicated by plant growth and defense to the pests. Consistent with the hypothesis, we found that integrating different trophic levels, i.e. maximum multitrophic biodiversity, could promote plant growth and notably the resistance to pest infestation through changing plant chemical composition. Particularly, we found microbivores reduced root biomass while omnivore-carnivores increased plant shoot biomass. The presence of omnivore-carnivores could suppress the abundance of insect (*brown planthoppers*) by regulating soil microbiome. In summary, the increment of soil multitrophic biodiversity have multifunctional consequence.

Overall, we provide direct experimental evidence for the multifunctional roles of soil multitrophic biodiversity. Further, soil organic management practices, regardless of organic amendments, non-tillage or growing cover crops, that improving soil habitat like resource and structure, and consequently promoting soil biodiversity especially higher-level biotic associations or trophic interactions may ultimately contribute to sustaining multiple ecosystem services including both crop productivity and pathogen controls. Such knowledge helps advance the mechanical

understanding of biotic drivers of soil ecosystem functioning. It also highlights that organic management could strengthen the carbon-based ecosystem services if considering the extra benefits provided by soil biodiversity. Overall, our study corroborated organic management will be crucial to implement an ecologically multifunctional agriculture.