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Carbon budgets of top- and subsoil food webs in an arable system

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ABSTRACT

This study assessed the carbon (C) budget and the C stocks in major compartments of the soil food web (bacteria, fungi, protists, nematodes, meso- and macrofauna) in an arable field with/without litter addition. The C stocks in the food web were more than three times higher in topsoil (0–10 cm) compared to subsoil (> 40 cm). Microorganisms contained over 95% of food web C, with similar contributions of bacteria and fungi in topsoil. Litter addition did not alter C pools of soil biota after one growing season, except for the increase of fungi and fungal feeding nematodes in the topsoil. However, the C budget for functional groups changed with depth, particularly in the microfauna. This suggests food web resilience to litter amendment in terms of C pool sizes after one growing season. In contrast, the distinct depth dependent pattern indicates specific metacommunities, likely shaped by dominant abiotic and biotic habitat properties.

1. Introduction

Plant C transfer by litter and roots into soils plays a vital role in regulating ecosystem responses to climate change (Bardgett, 2011). However, understanding the ecosystem functions of soil C storage requires knowledge of the linkages between plant C resources and belowground biota. While easily degradable substrates such as rhizodeposits are assumed to be metabolised quickly in the bacterial energy channel, recalcitrant litter likely fosters the fungal energy channel, working at slower rates (Moore et al., 2005; Holtkamp et al., 2011). Soil food webs therefore are crucial for the balance between C mineralization and sequestration (Bardgett and Wardle, 2010), yet empirical data on the C pools of functional groups are scarce. Only recently, root C incorporation into the soil food web of an arable soil was traced using a $^{13}CO_2$ pulse labelling of crop plants (Pausch et al., 2016).

Crop residues are important in the formation of soil organic matter, and for that reason often left on the field to maintain organic C stocks and to improve soil fertility. Agricultural practices that disturb soil C pools may increase greenhouse gas emissions and reduce soil quality (Turmel et al., 2015), which also applies to the management of food, fodder and bioenergy crops such as maize (Hudiburg et al., 2014). The aboveground inputs by maize to soil (to 1 m depth) were estimated between 70–81% of total plant C input, and indiscriminate removal of residues was shown to considerably diminish soil C stocks (Carvalho et al., 2017).

In contrast to the knowledge on the impact of crop management on soil C stocks, it is less clear how much C from above- ad belowground inputs is allocated to individual soil food web pools. Moreover, the availability and quality of plant C varies considerably with soil depth. Organic amendments are an important energy and nutrient source for soil communities predominantly in the plough layer (Navarro-Noya et al., 2013). In the rooted zone below the Ap horizon major resources are root residues and rhizodeposits, whereas organisms in the subsoil depend mainly on organic matter translocation from upper soil layers (Ferris and Bongers, 2006; Kautz et al., 2012).

The present study, for the first time, systematically elaborates the C stocks in all major groups of the soil food web up to 70 cm depth in an arable soil. The experimental field was cropped with *Zea mays* without and with application of maize shoot litter. The resulting two treatments were: fodder maize (FM), with the aboveground plant removed at

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