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Arbuscular mycorrhiza enhances rhizodeposition and reduces the rhizosphere priming effect on the decomposition of soil organic matter

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ABSTRACT

Arbuscular mycorrhizal fungi (AMF) represent an important route for plant carbon (C) inputs into the soil. Nonetheless, the C input via AMF as well as its impact on soil organic matter (SOM) stabilization and C sequestration remains largely unknown. A mycorrhizal wild type progenitor (MYC) and its mycorrhiza defective mutant (reduced mycorrhizal colonization: rmc) of tomato were continuously labeled with $^{13}CO_2$ to trace root C inputs into the soil and quantify rhizosphere priming effects (RPE) as affected by AMF symbiosis and N fertilization. Mycorrhizal abundance and ^{13}C incorporation into shoots, roots, soil and CO_2 were measured at 8, 12 and 16 weeks after transplanting.

AMF symbiosis decreased the relative C allocation (% of total assimilated C) to roots, in turn increased the net rhizodeposition. Positive RPE was recorded for both MYC and rmc plants, ranging from 16–71% and 25–101% of the unplanted control, respectively. Although net rhizodeposition was higher for MYC than rmc plants 16 weeks after transplanting, the RPE was comparatively lower. This indicated a higher potential for C sequestration by plants colonized with AMF (MYC) because the reduced nutrient availability restricts the activity of free-living decomposers. Although N fertilization decreased the relative C allocation to roots, rhizosphere and bulk soil, it had no effect on the absolute amount of rhizodeposition to the soil. The RPE and N-cycling enzyme activities decreased by N fertilization 8 and 12 weeks after transplanting, suggesting a lower microbial N demand from SOM mining. The positive relationship between enzyme activities involved in C cycling, microbial biomass C and SOM decomposition underlines the microbial activation hypothesis, which explains the RPE. We therefore concluded that AMF symbiosis and N fertilization increase C sequestration in soil not only by increasing root C inputs, but also by lowering native SOM decomposition and RPE.

1. Introduction

Globally, soils store 500–3000 Pg carbon (C), more than the atmosphere and biosphere together (Todd-Brown et al., 2013; Wieder et al., 2013). The global C storage depends on the balance between newly formed soil organic matter (SOM) and C lost through the decomposition of old SOM (Song et al., 2018). About half of total plant assimilated C is translocated from above-to below-ground pools, either as root and shoot litter or as rhizodeposits released from living roots (Zang et al., 2019). The soil CO_2 efflux is one of the largest fluxes in the global C cycle, with 50% controlled by plant-soil interactions (Hopkins et al., 2013).

There is increasing evidence that a significant part of this C enters and leaves the soil through the mycorrhizal network (Finlay and Rosling, 2006; Finlay, 2008). Arbuscular mycorrhizal fungi (AMF) are the dominant mycorrhizal type, forming symbiotic associations with about 71% of all flowering plants including many important crops such as

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