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A soil texture manipulation doubled the priming effect following crop straw addition as estimated by two models

Yuzhi Xu[a,c,1], Kai Liu[a,c,1], Ya Han[b], Heng Jiang[a], Shuihong Yao[b], Bin Zhang[b,*]

[a] National Observation Station of Hailun Agroecology System, Key Laboratory of Mollisols Agroecology, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Harbin, 150081, PR China

[b] National Engineering Laboratory for Improving Fertility of Arable Soils, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, 100081, PR China

[c] University of Chinese Academy of Sciences, Beijing, 100049, PR China

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ABSTRACT

Crop straw is often incorporated with soil tillage to maintain soil organic carbon (SOC). Both the crop straw addition *per se* and its associated soil structure changes can stimulate SOC decomposition, known as the priming effect. Yet no attempt has been made to isolate their effects. In addition, the priming effect is usually estimated by using uniformly labeled plant litters in the laboratory, and the impacts of non-uniform labeling on the estimation of the priming are poorly understood. The objectives of this study were 1) to isolate the effects of crop straw addition and soil structure changes on SOC decomposition and microbial community composition and 2) to evaluate the effects of the addition of pulse-labeled straw on estimation of the priming effects. The labeled ^{13}C content and its δ^{13}C abundance in the labile fractions of the straw sequentially extracted by ethanol, water and 0.1 M HCl were similar, but were much larger than those in the stable fractions exacted by 0.1 M NaOH. To identify the effects of soil structure changes, the soil texture of a surface soil was manipulated by adding fine sized particles (< 53 μm from the subsoil) into the soil. After straw addition, > 74 μm macroporosity of the texture-manipulated soil (MMS_1) increased, causing strong shifts in microbial community composition characterized by phosphorus lipid fatty acid profiling compared to non manipulated soil (NMS_1) during a 56-day incubation. The dynamics and total priming effects estimated using the end mixing model (EMM) based on the δ^{13}C abundance in the labeled straw and the improved priming model (PRIM) based on first-order SOC decomposition agree well. Total straw decomposition and total priming effect in the treatment MMS_1 were larger than those in the treatment NMS_1 by 175% and 170% with the EMM model, respectively. Our findings highlight the importance of understanding abiotic and biotic interactions underlying SOC turnover in the detritusphere of arable ecosystems.

1. Introduction

Soil organic carbon (SOC) plays a key role in maintaining soil fertility, mitigating effects of climate change, and offsetting many soil degradation processes (Lal, 2003). Straw incorporation is often encouraged to maintain SOC in arable lands. An addition of fresh organic materials can stimulate mineralization of native SOC, which is referred to as the priming effect (Bingeman et al., 1953; Kuzyakov et al., 2000; Kuzyakov, 2010). The priming effect is important to the increase of the nutrient availability of soils in the short term (Kuzyakov et al., 2000; Blagodatskaya and Kuzyakov, 2008), but may cause SOC losses in the long term (Wieder et al., 2013). An increased CO_2 emission associated with crop straw incorporation is often attributed to more aerated conditions by increasing soil macropore volumes with soil tillage (Strong et al., 1998, 2004; Yao et al., 2009). However, the effects of soil structure changes on SOC decomposition have not been isolated from those induced by organic inputs. Thus, understanding the relative contribution of crop straw addition and soil structure changes to the priming of native soil organic matter is relevant to optimization of crop straw incorporation practices. Furthermore, it is vital for the balance of long-term and short-term soil functions of crop residues.

Priming effect studies have mainly focused on its size and direction following addition of simple substrates (Hamer and Marschner, 2005; Dilly and Zyakun, 2008). The priming effect is generally considered to

* Corresponding author.
E-mail address: zhangbin01@caas.cn (B. Zhang).

[1] These authors contribute equally to this study.

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