Soil Biology and Biochemistry 135 (2019) 383–391

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Soil organic matter priming and carbon balance after straw addition is regulated by long-term fertilization

Lei Wu[a,b], Wenju Zhang[a], Wenjuan Wei[b], Zhilong He[b], Yakov Kuzyakov[b,c,f], Roland Bol[d,e], Ronggui Hu[b,*]

[a] Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences (CAAS), Beijing, 100081, PR China
[b] College of Resources and Environment, Huazhong Agricultural University, Wuhan, 430070, PR China
[c] Department of Soil Science of Temperate Ecosystems, Department of Agricultural Soil Science, University of Goettingen, Büsgenweg 2, 37077, Goettingen, Germany
[d] Institute of Bio- and Geosciences, Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, 52425, Jülich, Germany
[e] Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, Amsterdam, the Netherlands
[f] Institute of Environmental Sciences, Kazan Federal University, 420049, Kazan, Russia

ARTICLE INFO

Keywords:
Straw incorporation
Carbon sequestration
Priming effect
Long-term fertilization
Microbial necromass

ABSTRACT

Straw incorporation is crucial to soil organic carbon (SOC) sequestration, thus improving soil fertility and mitigating climate change. The fate of straw C and the associated net SOC balance remain largely unexplored, particularly in soils subjected to long-term mineral and organic fertilization. To address this, soil (δ^{13}C: –19‰) that had been continuously cropped with maize for 31 years and subjected to five long-term fertilization regimes, including (i) control (Unfertilized), (ii) mineral fertilizer (NPK) application, (iii) 200% NPK (2 × NPK) application, (iv) manure (M) application, and (v) NPK plus manure (NPKM) application, was incubated with or without addition of rice straw (δ^{13}C: –29‰) for 70 days. Straw addition largely primed SOC mineralization. The priming effect (PE) was considerably higher in 2 × NPK (+122% of CO_2 from soil without straw addition) but lower in M (+43%) relative to the unfertilized soil (+82%), highlighting the importance of fertilization in controlling PE intensity. Fertilization increased the straw-derived microbial biomass C by 90–577% and straw-derived SOC by 34–68% compared to the unfertilized soil, primarily due to the increased abundance of Gram-negative bacteria and cellobiohydrolase activity. Straw-derived SOC was strongly positively correlated with straw-derived microbial biomass C, suggesting that dead microbial biomass (necromass) was a dominant precursor of SOC formation. Consequently, fertilization facilitated microbial utilization of straw C and its retention in soil, particularly in the M and NPKM fertilized soils. The amounts of straw-derived SOC overcompensated for the SOC losses by mineralization, resulting in net C sequestration which was highest in the NPK fertilized soil. Our study emphasizes that NPK fertilization decreases the intensity of the PE induced by straw addition and increases straw C incorporation into SOC, thus facilitating C sequestration in agricultural soils.

1. Introduction

Soil organic carbon (SOC) is of fundamental importance to soil quality and fertility. Sustainable agricultural practices improve soil quality, ensure food security, and contribute to climate change mitigation through increasing SOC sequestration (Schmidt et al., 2011). Of the 3.8 Pg of crop straw (aboveground biomass) produced annually worldwide as agricultural byproducts, appropriate management of straw has important implications for increased soil nutrient availability, sustainable agricultural productivity, and our ability to minimize environmental pollution (LaI, 2005; Zhang et al., 2017). Straw incorporation into the soil is generally recommended for C sequestration in agroecosystems (Freibauer et al., 2004; Lu et al., 2009; Liu et al., 2014). However, straw addition may accelerate SOC mineralization and exert negligible or even negative impacts on soil C sequestration (Fontaine et al., 2004; Wang et al., 2011; Shahbaz et al., 2017a, 2017b). Despite numerous studies on the response of soil C dynamics to straw addition, the understanding of how C is actually sequestrated in the soil remains elusive, thus a thorough examination is warranted before the widespread implementation of straw application (Fontaine et al., 2003; Shahbaz et al., 2017a; Fang et al., 2018; Li et al., 2018).

Crop straw, containing large portions of labile C, is an essential source of C and energy for microorganisms (Qiu et al., 2016; Schmatz et al., 2017). Straw incorporation into the soil stimulates microbial

* Corresponding author.
E-mail address: rghu@mail.hzau.edu.cn (R. Hu).

https://doi.org/10.1016/j.soilbio.2019.06.003
Received 12 January 2019; Received in revised form 24 May 2019; Accepted 2 June 2019
Available online 04 June 2019