Applied Soil Ecology 130 (2018) 84–90

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Incorporation of rice straw carbon into dissolved organic matter and microbial biomass along a 100-year paddy soil chronosequence

Xiaofen Chen[a], Ming Liu[a,b], Yakov Kuzyakov[c,d,e], Weitao Li[a], Jia Liu[a,b], Chunyu Jiang[a], Meng Wu[a], Zhongpei Li[a,b,*]

[a] State Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] Department of Soil Science of Temperate Ecosystems, Department of Agricultural Soil Science, University of Goettingen, Büsgenweg 2, 37077 Göttingen, Germany
[d] Agro-Technology Institute, RUDN University, Moscow, Russia
[e] Institute of Environmental Sciences, Kazan Federal University, 420049 Kazan, Russia

ARTICLE INFO

Keywords:
Straw mineralization
Aerobic incubation
Dissolved organic matter
Microbial biomass
Paddy soil chronosequence
Stable isotopes

ABSTRACT

Dissolved organic matter (DOM) and microbial biomass (MB) are small but reactive pools of soil organic matter (SOM). The incorporation of carbon (C) from rice residue into DOM and MB in paddy soils under aerobic condition when rice straw remains in the field is poorly understood. A one-year incubation experiment was conducted, in which ^{13}C-labelled rice straw was added to a cultivation chronosequence of paddy soils ranging from 0 to 100 years. Rice straw was rapidly decomposed during the first 30 days, after which 73% of the added straw C, on average, was retained in the soil and 46% of the straw C remained in the soil after one year. Throughout the entire incubation period, 0.2–0.9% of the added straw C was incorporated into DOM, and 2–5% was recovered in MB. The paddy cultivation age strongly affected the straw contribution to the organic C pools. In barren land (0 year), 32–60% of the DOM was derived from straw C, while 13–30% of the DOM was derived from straw C in 5–100-year paddy soils. On average, straw C contributed to 88% of the MB in barren land, 50% in 5-year soil, and 13% in 100-year soil. Consequently, over the duration of paddy cultivation, the contribution of rice straw C to the MB decreased, while the contribution of SOM increased. Our study has indicated that DOM in paddy soils mainly originates from SOM rather than from added plant residues but that plant residues are an important C source for microorganisms.

1. Introduction

Maintaining soil C stocks is important for sustainable agricultural development and the mitigation of global warming by sequestrating atmospheric CO_2 belowground (Lal, 2004; Li et al., 2005). The return and incorporation of crop residues into soil is a widely used technique to maintain the organic C content in cropland, thereby improving soil fertility through the enhancement of physical, chemical and biological properties (Hadas et al., 2004; Lian et al., 2016). Understanding the dynamics and fate of crop residue C in soil helps to clarify the mechanisms of C sequestration and soil fertility development.

Crop residues contain readily decomposable C, such as hemicelluloses and pectin, providing substrates for soil microbes (Lorenz and Lal, 2005). The crop residue C passes through the soil microbial biomass at least once, is transferred from one C pool to another, and is finally mineralized to CO_2 (Ryan and Aravena, 1994; Williams et al., 2006). Undecomposed crop residues will remain in the soil and contribute to the soil C stock (Lorenz and Lal, 2005, Majumder and Kuzyakov, 2010). Dissolved organic matter (DOM) and microbial biomass (MB) are small but reactive pools of soil organic matter (SOM) (Liang et al., 2011; Pabst et al., 2013). Dissolved organic C is usually < 1% of the soil organic C, while microbial biomass C composes 2–3% (Jenkinson and Ladd, 1981; McGill et al., 1986; Zhao et al., 2008). Both DOM and MB turn over more rapidly and respond more quickly to soil management than total SOM and most other C pools (Blagodatskaya et al., 2011a; Chen et al., 2009; Guillaume et al., 2016). Based on stable isotope ^{13}C data, the fate of crop residue-derived C in SOM pools can be exactly traced. In a Luvisol (FAO Classification), 0.01% of added maize C was detected in DOM, 2% was present in MB, 21% was retained in soil, and 73% was released as CO_2 after incubation for 240 days (De Troyer et al., 2011). Another study found that 0.19–0.34% of maize C was present in DOM, 2.4–3.7% was present in MB, and 28% was retained in soil one year later (An et al., 2015). These and nearly all other long-term laboratory and field investigations have

* Corresponding author at: State Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008, China.
E-mail address: zhpli@issas.ac.cn (Z. Li).

https://doi.org/10.1016/j.apsoil.2018.06.004
Received 28 January 2018; Received in revised form 25 May 2018; Accepted 4 June 2018
Available online 19 June 2018
0929-1393/