Geoderma 357 (2020) 113941

Contents lists available at ScienceDirect

Geoderma

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

Effects of intensities and cycles of heating on mineralization of organic matter and microbial community composition of a Mollisol under different land use types

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ARTICLE INFO

Handling Editor: Jan Willem Van Groenigen

Keywords:
Heating
Soil respiration
Soil N mineralization
Microbial community composition
Mollisols

ABSTRACT

Soil heating at high temperatures was often found in greenhouse agriculture and high temperature extremes are predicted to occur more frequently in future climate. Yet, the influences of soil heating on soil organic matter decomposition, N mineralization, and the shift in microbial community composition are not well studied, particularly over multiple heating cycles and among different land use types. The main objectives of this study were 1) to investigate the effects of multiple heating cycles on soil respiration, N mineralization and soil microbial community composition, 2) to explore the relationships between soil microbial functions and community composition following heating cycles, and 3) to examine the influence of different land use types on soil microbial functions and community composition. The soils were sampled from an arable land, a forestland, and a grassland, and subjected to 25 °C constantly and to 40 or 50 °C for 18 h before being kept at 25 °C within 10 days for 3 cycles. At all temperature treatments, the forestland and the grassland had higher soil respiration rates, microbial biomasses and soil mineral N concentrations, compared to the arable land. In addition, the forestland and the grassland showed similar patterns of soil microbial community composition characterized by phospholipid fatty acid profiles (PLFA), but differed from that in the arable land. The soil respiration rates were enhanced by the increases in heating temperatures, and soil microbial biomass carbon (C) and N concentrations was reduced after heating at 40 °C, compared to these in the control treatment, and the reduction became more pronounced in heating treatment at 50 °C. With the increasing number of heating cycles, the soil respiration rate decreased after heating, but soil mineral N concentration was gradually enhanced, particularly in heating treatment at 50 °C. The principal component analysis of PLFAs demonstrated that soil microbial community composition shifted dramatically between days 21 and 30 (cycle 3), and between days 11 and 21 (between cycles 2 and 3, respectively), compared to that between days 1 and 11 (between cycles 1 and 2). The shift was consistent for all the land use types via PC1, but differed between the arable land and other land use types via PC2. Therefore, our findings suggested that cyclic heating drove changes in microbial composition, uncoupled soil C and N cycling during soil organic matter decomposition and could lead to a rapid decline of soil fertility and environmental quality under heating stresses.

1. Introduction

Soils are exposed to a range of natural and anthropogenic-induced stresses. In general, soils have abilities to withstand or adapt these stresses in order to continuously deliver soil functions essential for supporting production of food and fibre (Berard et al., 2015; Mueller et al., 2010). Soil microbial communities play a crucial role in many soil processes and functions such as the decomposition of soil organic matter (SOM), and the development of soil structure. Thus, maintaining the stability of soil functions in the context to environmental stresses is crucial in order to regulate the supplies of nutrients and water, therefore maintaining the sustainability of terrestrial system under future climatic conditions. Large increases in soil temperature were often observed in greenhouse agriculture (Sethi et al., 2004), and it is predicted that high temperature extremes will occur more intensively and frequently in future climate (IPCC, 2013). Thus an improved

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https://doi.org/10.1016/j.geoderma.2019.113941
Received 19 May 2019; Received in revised form 26 August 2019; Accepted 27 August 2019
0016-7061/