Applied Soil Ecology 138 (2019) 123–133

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Change in straw decomposition rate and soil microbial community composition after straw addition in different long-term fertilization soils

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ARTICLE INFO

Keywords:
Long-term fertilization practice
Straw return
Chemical fertilizer
Straw decomposition
Soil microbial community composition

ABSTRACT

Fertilization practices can change soil fertility and biological properties, and influence its ecological functions. We studied the change in the straw decomposition rate and microbial community composition in soils with different long-term fertilization regimes (no-fertilizer control (CK); nitrogen, phosphorus, and potassium fertilizers (NPK); and NPK plus straw (NPKS)) with addition of straw in a 75-day incubation experiment. Carbon dioxide (CO_2) emission rates from the straw material were 13.9, 15.8, and 17.9 μg C g^{-1} soil day^{-1} in the CK + S, NPK + S, and NPKS + S treatments, respectively. After straw addition, the biomass of fungi and bacteria increase following the order of CK + S ≤ NPK + S < NPKS + S; while the bacterial richness decreased and did not change with incubation time, the fungal richness decreased and presented different responses among treatments with incubation time. Their diversities presented a decreasing-increasing trend with incubation time in all treatments. The richness and diversity of bacteria and fungi were positively correlated with soil NO_3^-–N. Bacterial community structure on days 1 and 3 were significantly separated from that on day 75; however, fungal community structure did not differ significantly as that of bacteria across different stages in the same treatment. A redundancy analysis showed that straw addition changed the community structure of bacteria and fungi by decreasing soil NO_3^-–N, and their community structures were regulated by soil organic C in the early stage and by NH_4^+–N in the later incubation stage. The relative abundance of the bacterial phyla *Proteobacteria*, *Firmicutes*, and fungal phyla *Ascomycota* showed synchronized changes with straw CO_2 emissions rate. Our findings suggested that long-term fertilization and the return of straw to soils increased straw decomposition relative to the unfertilized soil, the latter difference in decomposition attributed to greater biomass of bacteria and fungi resulting from the improvement in soil fertility.

1. Introduction

Returning crop straw into fields can effectively improve soil fertility, carbon (C) sequestration and sustain soil productivity (Powlson et al., 2008; Malhi et al., 2011). Straw decomposition is a process of nutrient release, organic C mineralization, and soil organic C (SOC) balance (Grandy et al., 2013; Chen et al., 2014), primarily mediated by different soil microbes with specific functions (Marschner et al., 2011). It was reported that bacteria prefer to decompose labile compounds and dominate in the initial phases of straw decomposition (Stemmer et al., 2007; Paterson et al., 2011), while fungi can decompose more recalcitrant materials and dominate in the later stage (Marschner et al., 2011). Fan et al. (2014) indicated that the bacterial phyla *Actinobacteria*, *Firmicutes*, and *Proteobacteria* played a critical role in the decomposition of maize residues. Müller et al. (2017) found that fungi and bacteria all utilized labile C sources in the beginning of the decomposition process, and the relative values of ^{13}C-straw in fungal fractions was higher than the investigated bacterial fractions.

Microbial processes for straw decomposition are affected by straw quality and other abiotic factors influencing soil microbial activity and community composition, such as soil moisture and temperature, soil pH, SOC, nitrogen (N), and phosphorus (P) levels, and the C/N ratio (Henriksen and Breland, 2002; Geisseler et al., 2011; Kamble and Bååth, 2016). Wang et al. (2015) found that the straw-CO_2 emission rate was higher in secondary forest than in larch plantation soils, primarily due to an increase in the fungi after straw addition. Xu et al. (2016) showed that N addition promoted fungal growth, consequently increasing straw decomposition.

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https://doi.org/10.1016/j.apsoil.2019.02.018
Received 23 July 2018; Received in revised form 18 February 2019; Accepted 21 February 2019
Available online 06 March 2019
0929-1393/