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Microbial mechanisms of the contrast residue decomposition and priming effect in soils with different organic and chemical fertilization histories

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ABSTRACT

We integrated chemical, enzymatic, isotopic and molecular approaches to investigate both straw decomposition and its priming effect (PE) on native soil organic carbon (SOC) decomposition in soils with 23 years of application of chemical fertilizer (NPK) and partial substitution of chemical fertilizer by organic manure (NPKM). We found that NPK and NPKM past application significantly increased decomposition of straw. The increases in straw decomposition were not correlated with the abundances of microbiome assimilating straw carbon, but were significantly correlated with abundances of total bacteria, fungi and activities of cellulose-degrading enzymes. In addition, application of NPK did not change straw-induced PE while application of NPKM markedly reduced PE. The variation of PE with different past fertilization was correlated with the abundance of residue-stimulated fungi. The unchanged PE with NPK application in the presence of enriched nutrients and reduced pH was probably due to residue-promoted growth of acid-tolerant SOC-decomposing taxa (unclassified bacteria families belong to Acidobacteria GP3, Gamaproteobacteria and WPS-2 and unclassified fungal families belong to Chaetothyriales and Agaricomycetes). Our research sheds light on the complex processes of carbon transformation in the soils undergoing different long-term nutrient management.

1. Introduction

Crop residue and organic manure contain abundant organic carbon and elements essential for crop growth (Lal, 1995). Retention of crop residue and substitution of chemical fertilizer by organic manure (NPKM) not only save chemical fertilizer (NPK), but also increase the content of soil organic carbon (SOC) and reduce pollution (Edmeades, 2003). Interactions of straw retention with NPK and NPKM, especially in the long run, could change the efficiency of each technique. However, these practices have been investigated more often separately than together in previous reports (Davidson, 2009; Zhou et al., 2017). Comparison of the ways by which NPK and NPKM long-term applications influence straw decomposition and the involved microbial mechanisms is largely unexplored.

The processes of organic carbon decomposition in soil are complex. Previously, it has been generally accepted that residue decomposition rates are controlled by macroclimate at the large geographic scale (Meentemeyer, 1978), and by litter chemical composition and nutrient contents at the local scale (Meentemeyer, 1978; Melillo et al., 1982). For instance, residue rich in lignin decomposes slowly (Meentemeyer, 1978), while residue with a large initial N content decompose quickly (Melillo et al., 1982). Phosphorus, potassium and micronutrients contents also greatly influence litter decomposition (Kaspari et al., 2008). More recently, microbial community was found to be another important regulator on the litter decomposition (Strickland et al., 2009; Gessner et al., 2010; Bardgett and van der Putten, 2014). The soil microbiome is extremely diverse and is largely shaped by soil type (Girvan et al., 2003). Not all microbes in the community are involved in decomposing the litter carbon as a large proportion of them are inactive, dormant or feed on other substrates (Bernard et al., 2007; España et al., 2011;

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