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Soil nutrient and microbial activity responses to two years after maize straw biochar application in a calcareous soil

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ABSTRACT

Biochar (BC) addition to soil is a strategy to enhance soil fertility, which may also affect microbial activity. However, little information is available on the responses of soil nutrients and microbial activities to BC in a calcareous soil. This study investigated the changes of soil nutrient contents and microbial activities in a calcareous soil two years after application of biochar at rate of 0, 2.5, 7.5 and 22.5 t/ha. The results showed that the contents of soil organic carbon (SOC), total nitrogen (TN), dissolved organic carbon (DOC), total dissolved nitrogen (TDN), and available phosphorus and potassium increased significantly with increasing BC addition rate, but no significant effect on soil pH. Soil microbial biomass carbon and nitrogen (MBC and MBN) had an increased and then decreased trend. BC amendment increased microbial biomass and promoted soil carbon- and nitrogen-cycling enzyme activities, the ratios of β-glucosaminidase/phosphomonoesterase, N-acetyl-β-glucosaminidase plus leucine aminopeptidase/phosphomonoesterase increased significantly with increasing BC addition rate. Redundancy analysis confirmed that DOC and MBN were dominant factors affecting soil microbial biomass, and soil pH, TDN, DOC, MBN and SOC were main factors regulating soil enzyme activities. Besides, principal component analysis revealed that difference in microbial community composition in one year after BC addition was mainly associated with the relative abundance of bacteria and fungi, the relative abundance of bacteria increased, while the ratios of Gram-negative/Gram-positive bacteria and fungi/bacteria, and relative abundance of fungi and arbuscular mycorrhizal fungi decreased in BC-amended soils with control. However, BC had no significant effect on microbial community composition after two years. These results suggest that application of maize BC to calcareous soils may have a great potential for improvements in the soil nutrients and enzyme activity, the changes in soil microbial composition deserve further studies.

1. Introduction

Biochar (BC) is a solid organic substance produced by thermochemical conversion under oxygen-limited conditions. It is estimated that the BC carbon (C) residence time in the soil is hundreds to thousands of years, whereas the residence time of crop residues is several decades (Lehmann et al., 2006). This makes BC attractive as a soil amendment option for C sequestration because it has the potential to improve soil properties and functions relevant to agronomic and environmental performance (Lehmann, 2007; Woolf et al., 2010). Previous studies have reported that BC can increase soil nutrient holding capacity, nutrient supply capacity, nutrient availability, soil fertility, and plant performance, thus exerting a fertilizer effect on crop growth and yield (Butnan et al., 2015; Kameyama et al., 2012; Wan et al., 2014). The effect of BC on soil fertility is predominantly mediated through the increase in pH in acidic soils (Zwieten et al., 2010) or by increasing soil cation adsorption to improve nutrient retention (Liang et al., 2006). However, previous findings are inconsistent, with positive and negative effects of BC reported, and the long-term effects remain uncertain (Bruun et al., 2013; Tammeorg et al., 2014; Viger et al., 2015).

Experimental evidence shows that the addition of BC has an important impact on soil microbial communities and performs a critical role in maintenance of soil health and function (Lehmann et al., 2011; Rondon et al., 2007; Steiner et al., 2010; Warnock et al., 2007). Changes in microbial community composition or activity induced by BC

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