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Soil microbial community structure and function are significantly affected by long-term organic and mineral fertilization regimes in the North China Plain

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ABSTRACT

An improved understanding of the complex interactions and relationships in the soil ecosystem is essential to predict the impact of farming practices on soil quality and its capacity for agricultural production. This study aims to improve our understanding of the impacts of fertilization strategy on key indicators of soil biological and chemical quality. We studied soils from a winter wheat-summer maize rotational experiment in the North China Plain with six different fertility treatments: no amendments (CK); standard mineral fertilizer treatment (SMF) or standard organic manure treatment (SMA) reflecting local farmer practice; mixed treatment with fertilizer and manure at half the rates for the SMF and SMA treatments (1/2 SMF + 1/2 SMA); double mineral fertilizer treatment (DMF); and double organic manure treatment (DMA). Soil organic C (SOC), total N (TN), total P (TP), pH, and dissolved organic C (DOC) and N (DON) and microbial biomass C (Cmic) and N (Nmic) were determined using standard methods. Soil bacterial community structure was assessed by denaturing gradient gel electrophoresis (DGGE), and activities for 10 extracellular enzymes (EEAs) were measured as indicators of soil function. Repeated application of either organic manure or mineral fertilizer increased SOC, TN, TP, DOC, DON, Cmic and Nmic, and decreased soil pH. Higher rates of organic manure fertilization significantly affected soil chemical properties compared to the lower rate. Soil bacterial community structure was significantly altered by the long-term fertilization regimes and diversity was significantly higher in the double manure rate treatment relative to mineral fertilizer. The higher urease, α-glycosidase, *N*-acetyl-β-glucosaminidase, L-leucine aminopeptidase (involved in N cycling), β-glucosidase, β-xylosidase and β-cellobiosidase (involved in C cycling), and alkaline phosphatase (involved in P cycling) activities for organic manure fertilized soils reflected a higher nutrient cycling capacity compared to mineral fertilized and control plots. Soil bacterial community diversities increased with Cmic and variations in EEAs were strongly correlated with soil DOC availability. Our study has demonstrated that a long-term fertilization strategy can be used to improve soil quality. Clearly, the use of organic fertilizers where available, is a win–win strategy for maintaining soil quality and crop productivity, while ensuring the delivery of soil ecosystem services into the future.

1. Introduction

Chinese agriculture has intensified greatly since the early 1980s on a limited land area with large inputs of mineral fertilizers and other resources to meet the food demand of its increasing population (Guo et al., 2010). Cereal grain yields have increased by 65% between 1980 and 2010 (Zhang et al., 2012), but this success has come at a cost: overuse of mineral fertilizer not only induces low fertilizer use efficiency and the rapid depletion of known

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