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Substituting ecological intensification of agriculture for conventional agricultural practices increased yield and decreased nitrogen losses in North China

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ABSTRACT

There is global concern about the adverse impacts of conventional agricultural practices on the environment. Recent evidence has shown that ecological intensification (EI) of agriculture can safeguard the environment from negative impacts of agricultural practices and simultaneously produce substantially higher crop productivity. Here, we employed the concept of EI and compared it with conventional agriculture or farmer's practice (FP). We explored the effects of EI and FP treatments on maize yield, N losses via potential nitrification activity (PNA), potential denitrification activity (PDA), N_2O emissions, greenhouse gas (GHG) emissions, and nitrogen (N) cycling microbial populations associated with nitrification and denitrification in fluvo-aquic soil and black soil of North China. There were four treatments, i.e., EI N-, FP N-, EI N+, FP N + at each site, - and + indicate no N addition and N addition, respectively. The results revealed that across the two soils, N addition increased PNA and PDA; however, compared with the FP N + treatment, lower PNA and PDA were observed in the EI N + treatment. Similarly, the abundance of N cycling genes, including AOA *amoA* and AOB *amoA,* for nitrification and *nirS*, *nirK*, and *nosZ* for denitrification were significantly increased under N addition, and compared with the FP N + treatment, reduced abundance was noted in the EI N + treatment. N_2O and GHG emissions were quantified, and it was observed that, in comparison to the FP treatment, reduced N_2O and GHG emissions occurred in EI treatments in the two locations. EI with best management practices also increased crop yield relative to FP. Owing to higher N rates in FP treatments, substantial soil acidification was noted in FP plots but not in EI plots. In addition, PNA and PDA were significantly positively linked with soil nitrifying and denitrifying communities, particularly in the black soil. Moreover, the N availability pathway rather than soil acidification mainly regulated N cycling microbial communities. Our results suggest that EI could be a sustainable and environmentally friendly approach due to higher crop productivity and lower N losses via PNA, PDA, N_2O, and GHG emissions, thus preventing the negative impact of agricultural practices, especially N fertilization, on the environment.

1. Introduction

The human population has hit the highest numbers ever recorded, and in upcoming decades, we will observe a tremendous increase in food demand that will definitely create huge pressure to produce more food from the same amount of arable land (Godfray et al., 2010). In fact, agricultural land has only increased by 9 % while human population doubled since 1961 (Pretty, 2007; UN, 2019). To address this issue, scientists have proposed the Green Revolution, which is characterized by the addition of inorganic fertilizers, pesticides, conventional tillage, and crop breeding (Tilman et al., 2001). Although conventional agriculture or agricultural intensification has successfully solved the issue of food security by increasing crop productivity, substantial negative impacts on biodiversity and the environment are becoming more evident (Moss, 2007; Potts et al., 2010). It is well accepted that crop production is not possible without fertilization, particularly nitrogen (N) fertilization, which has a critical role in crop production (Gruber and Galloway, 2008). There is no doubt that N fertilization has improved crop productivity but has also resulted in serious environmental issues, such as elevated greenhouse gas emissions, e.g., nitric

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