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RESEARCH ARTICLE

Decrease in the annual emissions of CH_4 and N_2O following the initial land management change from rice to vegetable production

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Abstract

In recent years, rice paddies have been increasingly converted to vegetable production resulting from economic benefits and changes in demand of diets, potentially altering soil greenhouse gas (GHG) balance. Here, we implemented a parallel field experiment to simultaneously quantify the differences in emissions of CH_4 and N_2O among rice paddy (RP) and conventional vegetable field (CV) and greenhouse vegetable field (GV), both of which have been recently converted from rice paddy in subtropical China over a full year. The results revealed that CH_4 emission was reduced dramatically by nearly 100% following the initial land management change from rice to vegetable production, with annual emissions of 720.9, 0.9, and 0.2 kg CH_4-C ha^{-1} for RP, CV, and GV, respectively. This conversion however substantially increased N_2O emissions, resulting in the transition from a minor sink of N_2O in RP (−0.1 kg N ha^{-1} yr^{-1}) to considerable N_2O sources in CV (31.8 kg N ha^{-1} yr^{-1}) and GV (52.2 kg N ha^{-1} yr^{-1}). Furthermore, annual N_2O emission from GV significantly exceeded that from CV due to lower soil pH and higher soil temperature facilitating N_2O production in GV relative to CV. Land management change significantly decreased the annual total emissions of CH_4 and N_2O from CV and GV by 19–51% as compared to RP, attributing to the reduced CH_4 emissions outweighing the increased N_2O emissions in CV and GV. These results indicate that expansion of vegetable production at the expense of rice paddies for higher economic benefits also helps mitigate the total emissions of CH_4 and N_2O.

Keywords Land management change · CH_4 · N_2O · Rice paddy · Vegetable field

Introduction

Atmospheric methane (CH_4) and nitrous oxide (N_2O) are generally regarded as the two major non-CO_2 greenhouse gases (GHGs), with relative global warming potentials (GWPs) of 28 and 265 times that of carbon dioxide (CO_2) over a time scale of 100 years, respectively (IPCC 2013). Agriculture and associated land management change serves as a significant source of CH_4 and N_2O which together contribute to more than one quarter of the total anthropogenic radiative forcing (IPCC 2013; Zhang et al. 2014). Changes in agricultural land management have direct impacts on soil environment conditions and consequently influence the biogeochemical cycling of C and N and thereby production and emission of GHGs from soils (Eusufzai et al. 2010; Weller et al. 2016; Zhang et al. 2016a).

China is one of the most important rice producers in the world, accounting for 20% of the world's rice-producing area and 23% of all China's cultivated land (FAO 2013). Numerous field studies and modeling approaches have documented CH_4 and N_2O emissions from rice paddies (Zhou et al. 2015; Kraus et al. 2016; Weller et al. 2016; Zhang et al. 2016a), which are estimated to emit 4.8 Tg CH_4-C yr^{-1} and 114.5 Gg N_2O-N yr^{-1} in China, respectively (Zhang et al. 2014). Over the last decades, because of economic benefits and changes in demand of diets, rice paddies have been increasingly undergoing shifts in land-use regimes, such as conversion of rice cropping systems to upland crop cultivations, including maize, fruits, and vegetables (Shen et al. 2008; Sun et al. 2011; Kraus et al. 2016).

China ranks as the leading country of vegetable cultivation in the world, contributing 52% of the world's total vegetable production in 2012 (FAO 2013). The vegetable cultivation area extends over 24.7×10^6 ha, accounting for about 12.4%

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