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ORIGINAL ARTICLE

Effect on greenhouse gas balance of converting rice paddies to vegetable production

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Abstract Rice paddies are increasingly being converted to vegetable production due to economic benefits related, in part, to changes in demand during recent decades. Here, we implemented a parallel field experiment to simultaneously measure annual emissions of CH_4 and N_2O, and soil organic carbon (SOC) stock changes, in rice paddies (RP), rice paddy–converted conventional vegetable fields (CV), and rice paddy–converted greenhouse vegetable fields (GV). Changing from rice to vegetable production reduced CH_4 emissions by nearly 100%, and also triggered substantial N_2O emissions. Furthermore, annual N_2O emissions from GV significantly exceeded those from CV due to lower soil pH and higher soil temperature. Marginal SOC losses occurred after one year of cultivation of RP, CV, and GV, contributing an important share (3.4%, 32.2%, and 10.3%, respectively) of the overall global warming potential (GWP) balance. The decline in CH_4 emissions outweighed the increased N_2O emissions and SOC losses in CV and GV, leading to a 13%–30% reduction in annual GWP as compared to RP. These results suggest that large-scale expansion of vegetable production at the expense of rice paddies is beneficial for mitigating climate change in terms of the overall GWP.

Keywords Greenhouse gas balance · Land management change · CH_4 · N_2O · Soil organic carbon

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1 Introduction

Over the last few decades, because of water scarcity, economic benefits, and changes in diets, rice paddies have been increasingly subject to shifts in the land-use regime, such as conversion of rice cropping systems to upland crop cultivation like maize, fruits, and vegetables (Sun et al. 2011). Conversion of rice to vegetable cultivation significantly reduces CH_4 emission, but can induce increases in N_2O emissions as well as soil organic carbon (SOC) losses due to aerobic conditions, which facilitate N transformation and SOC mineralization (Weller et al. 2016). It remains unclear whether the positive effects of CH_4 mitigation can be negated by the corresponding increases in N_2O emissions and SOC losses. In this study, we evaluated the short-term effects of land-management change from rice to vegetable production on annual CH_4 and N_2O emissions, SOC stocks, and the resulting overall global warming potential (GWP).

2 Materials and methods

The selected experimental plots had been cultivated with double rice cropping for at least 100 years prior to 2013 in Hunan Province, China. Portions of these rice paddy fields were randomly assigned to be converted to vegetable cultivation—either in fields or greenhouses—after late rice harvest in October 2013. The experiment began in October 2014 and lasted over a year with three treatments: rice paddy (RP), rice paddy-converted conventional vegetable (CV), and rice paddy-converted greenhouse vegetable (GV) plots in a randomized block design with three replicates of each treatment. Field management followed local conventional practices.

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