Biol Fertil Soils
DOI 10.1007/s00374-017-1206-0

ORIGINAL PAPER

The effects of silicon fertilizer on denitrification potential and associated genes abundance in paddy soil

Alin Song[1] · Fenliang Fan[1] · Chang Yin[1] · Shilin Wen[1] · Yalei Zhang[1] · Xiaoping Fan[2] · Yongchao Liang[2]

Received: 5 January 2017 / Revised: 26 April 2017 / Accepted: 1 May 2017

Abstract This study evaluated the effect of silicate fertilizer on denitrification and associated gene abundance in a paddy soil. A consecutive trial from 2013 to 2015 was conducted including the following treatments: control (CK), mineral fertilizer (NPK), NPK plus sodium metasilicate (NPK + MSF), and NPK plus slag-based silicate fertilizer (NPK + SSF). Real-time quantitative PCR (qPCR) was used to analyze the abundances of *nirS*, *nirK*, and *nosZ* genes. Potential N_2O emissions and ammonium and nitrate concentrations were related to the *nirS* and *nirK* gene abundance. Compared with the NPK treatments, the addition of a Si fertilizer decreased N_2O emission rates and denitrification potential by 32.4–66.6 and 22.0–59.2%, respectively, which were probably related to increased rice productivity, soil Fe availability, and soil N depletion. The abundances of *nirS* and *nirK* genes were decreased by 17.7–35.8% and 21.1–43.5% with addition of silicate fertilizers, respectively. Rates of total N_2O and N_2O from denitrification (DeN_2O) emission were positively correlated with the *nirS* and *nirK* gene abundance. Nitrate, exchangeable NH_4^+, and Fe concentrations were the main factors regulating the *nirS* and *nirK* gene abundance. Silicate fertilization during rice growth may serve as an effective approach to decreasing N_2O emissions.

Keywords Denitrification · N_2O emission · *nirS* · *nirK* · Rice · Silicon

Alin Song and Fenliang Fan contributed to this work equally.

✉ Yongchao Liang
ycliang@zju.edu.cn

[1] Key Laboratory of Plant Nutrition and Fertilizer, Ministry of Agriculture, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, People's Republic of China

[2] Ministry of Education Key Laboratory of Environment Remediation and Ecological Health, College of Environmental and Resource Sciences, Zhejiang University, Hangzhou 310058, China

Introduction

Nitrous oxide (N_2O) is one of the important greenhouse gases contributing to 6% of the total global warming. On a molar basis, N_2O has 265 times higher global warming potential than carbon dioxide (CO_2) (Stocker et al. 2013). It has been reported that N_2O can also lead to stratospheric ozone layer depletion. Therefore, it is necessary to find appropriate strategies to mitigate N_2O emission. Agriculture is assumed to be one of the main sources of N_2O, because it accounts for approximately 84% of the total anthropogenic N_2O emissions worldwide (Smith and Ogram 2008). The emissions of N_2O from agricultural soils can be controlled by climatic condition, soil factors, and agricultural management, especially fertilizer application (Zhang et al. 2015).

Rice is one of the important cereal crops worldwide. It is estimated that the rice-growing areas in China account for approximately 20 and 23% of the world total and all cultivated lands, respectively (Frolking et al. 2002). The average N_2O emission from Chinese paddy soils is approximately 29 Gg N_2O-N during the rice-growing season, accounting for 7–11% of the estimated annual total emission from croplands in the mainland of China (Forster et al. 2007; Zou et al. 2007), which may increase further due to expansion of rice cultivation to meet the increasing food needs for the growing population (Smith et al. 2007). Nitrification and denitrification are thought to be the main N_2O-producing processes driven by microbes (Conrad 1996). However, N_2O emission is reported to be attributed mainly to denitrification in paddy soils due to the anaerobic conditions (Lan et al. 2015; Ji et al. 2013). Therefore, it is of great importance to investigate denitrification and

Published online: 12 May 2017