Environmental Science and Pollution Research (2020) 27:2087–2095
https://doi.org/10.1007/s11356-019-06776-6

RESEARCH ARTICLE

Combined effects of nitrification inhibitor and zeolite on greenhouse gas fluxes and corn growth

Oslan Jumadi[1] · **Yusminah Hala**[1] · **R. Neni Iriany**[2] · **Andi Takdir Makkulawu**[2] · **Junja Baba**[3] · **Hartono**[1] · **St. Fatmah Hiola**[1] · **Kazuyuki Inubushi**[3]

Received: 11 September 2017 / Accepted: 15 October 2019 / Published online: 26 November 2019

Abstract

Field and incubation experiments were conducted to determine the emission rate of greenhouse gases, nitrogen change, populations of AOB, NOB, and fungi as well as growth of corn in response to amendment of urea granulated with and without nitrification inhibitors and zeolite. The application of urea with neem, urea with zeolite, urea with zeolite + neem, urea with zeolite + dicyandiamide, and urea with dicyandiamide (UD) decreased the N_2O emissions by 16.3%, 59.6%, 66.8%, 81.9%, 16.3%, and 86.7%, respectively. Meanwhile, patterns of CH_4 fluxes were mostly determined by small emissions. Increase in corn height, weight of cobs, biomass, and chlorophyll leaf contents were not significantly different between urea alone and urea with NIs and zeolite. In the incubation experiment, the highest concentration of NH_4^+ and N_2O production was detected during the first week and it remained high up to the second week of incubation in the combination of urea with NIs and zeolite treatments, although there was no significant difference compared with urea. During NH_4^+ decrease, the concentration of NO_3^- started to accumulate from the second to the third weeks. Production of CO_2 showed no significant differences among treatments. The static production of CO_2 could also explain that NIs and zeolite additions did not change AOB, NOB, and fungi activities after the fourth week of incubation.

Keywords Emission of N_2O and CH_4 · CO_2 Production · Dicyandiamide · Neem · Nitrification inhibitor · Zeolite

Introduction

Urea ($CO(NH_2)_2$ has been widely used by farmers as a major source of nitrogen fertilizer to support corn production which is the second most important cereal after rice in Indonesia. The worldwide demand for urea was forecasted to increase from 148 Mt in 2010 to 171.7 Mt in 2015, representing a growth of 3.2% per annum (IFA 2011). Nitrogen (N) is more substantial in a plant and needs larger quantities than other nutrients and it is estimated that only 30–40% of the application of N fertilizer is taken up by the crop. Most of it disappears by ammonia volatilization, nitrification, and denitrification. Therefore, the use of urea in the agriculture sector in order to increase the quantity and quality of agricultural food production can generate a negative impact on the environment, such as ozone layer depletion due to enhancement of greenhouse gas emissions, particularly nitrous oxide (N_2O) gas (Mosier and Kroeze 2000).

Emission of N_2O gas in agricultural land is determined by the nitrification process in aerobic soil conditions and formed nitrate (NO_3^-) that has mobility capacity to leach as a pollutant to the environment. The NO_3^- is susceptible to denitrification loss in anaerobic conditions in soil or water. In addition, that process is also a cause of low use nitrogen fertilizer efficiency in the agricultural sector (Mosier and Kroeze 2000). The process of release of N_2O from the soil into the atmosphere is influenced by diffusion processes in the soil and the capacity of soil to consume N_2O, which is determined by several factors such as the production footprint in the soil, soil organic matter, soil texture, and soil water content (Zhang et al. 2017; Majumdar et al. 2002; Jumadi et al. 2014).

Responsible editor: Philippe Garrigues

✉ Oslan Jumadi
oslanj@unm.ac.id

[1] Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar 90224, Indonesia

[2] Plant Breeding, Cereals Research Institute, Maros 90514, Indonesia

[3] Graduate School of Horticulture, Chiba University, Matsudo, Chiba 271-8510, Japan