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Global Warming Potential of Diversified Tropical Rice Rotation Systems after Straw Return and Legume Intercropping

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Abstract

Paddy rice cultivation is increasingly challenged by irrigation water scarcity, which is forcing farmers to change traditional rice cultivation from flooded double-rice systems to the introduction of well-aerated upland crops during dry season. Emissions of methane (CH_4) are expected to decrease, while there is a risk of increasing emissions of nitrous oxide (N_2O) and decreasing soil organic carbon (SOC) stocks through volatilisation in the form of carbon dioxide (CO_2). We present a unique dataset of long-term continuous greenhouse gas emission measurements (CH_4 and N_2O) in the Philippines to assess global warming potentials (GWP) of diversified rice crop rotations including different crop management practices such as straw residue application and mungbean intercropping.

Since 2012, more than four years of CH_4 and N_2O emissions in double-rice cropping (R-R) and paddy rice rotations diversified with either maize (R-M) or aerobic rice (R-A) during dry season have been collected. Introduction of upland crops reduced irrigation water use and CH_4 emissions by 66–81 % and 95–99 %, respectively. Although annual N_2O emissions increased twice- to threefold in the diversified systems, the strong reduction of CH_4 led to a significantly lower annual GWP (CH_4^+ N_2O) as compared to the traditional R-R system.

Diversified crop management practices were first implemented during land-preparation for dry season 2015 where i) 6 t ha^{-1} rice straw was returned to the field and ii) mungbean was grown as a cover-crop between dry and wet season in addition to rice straw application. The input of organic material (straw and mungbean) led to higher substrate availability for methanogens during the following season. Therefore, GWP was 9–38 % higher following straw incorporation than the control treatment. This increase was mainly driven by increases in CH_4 emissions. Due to both stimulating CH_4 and N_2O emissions mungbean intercropping further increased GWPs, whereby the increase was highest in the R-R rotation (89 %) and lowest in the R-M rotation (56 %).

Nevertheless, regarding a future expansion of lowland-upland rotations due to water scarcity in SE-Asia it can be expected that input of crop residues can counteract the SOC loss that is likely associated with the shift to more aerated soil conditions under upland crops.

Keywords: GWP, maize, methane, mungbean, nitrous oxide, paddy rice, residue management, SOC

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