Seasonal variations in methane emissions via plant and ebullition from rice paddies

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It is well known that rice paddies are one of the important sources for methane emissions. Methane is released from rice paddies into the atmosphere via three pathways: molecular diffusion of dissolved methane across the atmosphere-water boundary, ebullition of gas bubbles, and diffusive transport through the aerenchyma tissue of rice plant. Transport through the rice plant has long been believed to be the dominant pathway; however, portable methane analyzers with high precision and high-time-resolution have recently revealed that ebullition also greatly contributes to the total emission. The purpose of this study was to clarify the seasonal variation of methane fluxes via ebullition and rice plant separately, and to identify factors affecting each pathway in a Japanese rice paddy.

Field monitoring was conducted at a continuously flooded rice paddy in Tsukubamirai City, Ibaraki Prefecture, Japan. The monitoring periods were from 27-May to 24-Sep., 2021. Four different treatments were set: rice paddies with/without rice plant (*Oryza sataiva*, cv Koshihikari) and with/without straw application, with three replications. The dimension of the plot was 30 cm x 60 cm with four hills of rice (for plots with rice plants), each consisting of three rice plants. TEROS-12 sensors for measuring soil moisture, soil temperature, and electric conductivity (EC) were installed at 5 cm and 10 cm depths in each plot. Methane emissions were measured weekly using a closed-chamber method with a portable spectroscopic gas analyzer (G4301, Piccaro, Inc., CA, USA). Methane emissions via rice plants and by ebullition were separately quantified following Kajiura and Tokida (2021).

High methane ebullition rates, accounting for >50% of the total emission, were observed during heading (HD) stage. The application of rice straws increased both methane fluxes via rice plant and ebullition during panicle formation (PF) and booting (BT) stages. Throughout the growth period, soil temperature, atmospheric pressure, and volumetric air content (i.e., bubble volume) were not correlated with the magnitude of ebullition, while a positive correlation was observed between plant-mediated emission and bubble volume during PF and BT stages.

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