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Management of rice paddy fields affects greenhouse gas emissions

How rice paddy fields are managed significantly influences the release of greenhouse gases (GHGs), a recent study concludes. Permanently flooded soils release more methane than soils that are flooded and then dried between production periods, for example. In general, the researchers recommend growing other crops in dried soil between production cycles, as well as limiting nitrogen fertilisers, to minimise the release of methane and nitrous oxide.

Rice paddy fields are a source of the GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The extent of GHG emissions depends on: how the land is used; whether/which other plants are grown in rotation with the rice; organisms living in the soil; soil chemical and physical properties; and climate.

The management of rice paddy fields influences the amount of CH_4 and N_2O emitted. When fields are flooded, anaerobic (no oxygen) soil conditions produce CH_4. N_2O can be produced by soil microbes in both aerobic (oxygenated) and anaerobic soils and emissions are largely dependent on nitrogen inputs (e.g. fertiliser). Typically, N_2O emissions are low in permanently flooded fields but CH_4 emissions are high, and there is a trade-off between them, depending on rice paddy water-management practices.

To develop strategies for growing rice that minimise the release of CH_4 and N_2O, this study investigated how past management of rice paddies has affected GHG emissions. The researchers focused on the effects of water management and the length of time paddy fields are flooded. They also evaluated how soil samples are prepared in the laboratory, as different preparation methods may affect results. Soil samples were treated in three ways: dried and sieved (dry); dried, sieved and incubated for a week before use; or used fresh.

The researchers took soil samples from four differently managed rice paddies in northern Italy: a two-year old paddy; a one-year old continuously flooded paddy; a one-year old paddy that had been flooded and dried; and an aerobic field that had never been flooded. All soils had similar chemical characteristics and textures and, as they experienced the same climatic conditions, the researchers inferred that differences in GHG emissions and soil microbial composition reflected water-management practices and soil-preparation methods.

To evaluate the GHG emissions of the different soils, the researchers incubated the samples with water in sealed flasks in a water bath at 25 °C, starting with 1% oxygen in the headspace. The experiment was run until all the oxygen was consumed and the researchers collected and analysed gases released from the soil samples during the course of the experiment.

Dry soils produced the most CO_2, CH_4 and N_2O, compared with the other two preparation methods. For example, permanently flooded soil that had been dried produced 0.173 milligrams of methane per gram of soil (mg/g); permanently flooded soils that had been preincubated produced 0.077 mg/g and fresh soils produced 0.107 mg/g. This suggests that breaking up the soil during preparation makes more soil matter available for soil microbes to act on.

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Past management also had a significant impact on GHG production. For all preparation methods, aerobic soil that had never been flooded produced the most N_2O and the least CH_4. They found the reason for these differences was changes to the composition of bacteria and Archaea (a group of soil microbes) in the soil, which are responsible for the release of GHGs.

This study provides the first indications of how soil-management practices affect soil microbe communities. The researchers suggest general ways to manage rice paddies to minimise the release of GHGs. To reduce CH_4 emissions, they suggest limiting microorganisms responsible for methane production by alternatively growing rice in flooded soils with growing crops that require aerobic conditions, in the same, but dry soils.

To counter increased N_2O emissions, produced by organisms typically found in aerobic soils, the researchers say the application of nitrogen fertilisers should be carefully controlled to limit the nitrogen available for the growth of these organisms.

They further suggest that field studies are needed to better understand the processes that affect the composition and functioning of soil microbial communities in differently managed rice paddies. Such studies should also address other factors that influence emissions from soils, including oxygen and nutrient availability in the root zone, carbon uptake and respiration, which were not addressed in this study.