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Decomposition, greenhouse gas emissions, and nitrogen release of rice straw and its derived biochar in paddy soil under anaerobic incubation

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Abstract

Organic soil amendments like rice straw improve soil fertility through the decomposition process. However, the decomposition under anaerobic conditions results in CH_4 production. Using pyrolysis to produce biochar may reduce CH_4 production and subsequently affects nutrient availability such as nitrogen in soils. This research investigated the effects of the application of rice straw (RS, 10 t ha^{-1}) and its derived biochar (BC, 3 t ha^{-1}) on decomposition, greenhouse gas emissions, and nitrogen release in a 56-day anaerobic incubation experiment of submerged paddy soil. Our results showed that the RS treatment had the highest CO_2 and CH_4 emission rates, while the BC treatment had significantly lower emission rates, similar to the control. The CO_2 emission rate of RS was higher than the BC and control from day 3, with the highest value at week 5 (352.6 g CO_2 m^{-2} d^{-1}). Meanwhile, the CO_2 emission rate in BC increased after two weeks and was highest at week 6 (146.6 g CO_2 m^{-2} d^{-1}). Conversely, the CH_4 emission rate of all treatments gradually increased after week 2. RS soil had the highest CH_4 emission rate at week 5 (757.1 g CH_4 m^{-2} d^{-1}) and BC soil had the highest CH_4 emission rate at week 4 (1.11 g CH_4 m^{-2} d^{-1}). Extractable NO_3^- content was higher in RS than in BC, while extractable NH_4^+ content was higher in BC than in RS. The highest contents of extractable NO_3^- and NH_4^+ in RS treatment were found in weeks 3 (4.7 mg kg^{-1}) and 4 (165.0 mg kg^{-1}), respectively. Meanwhile, the highest contents of extractable NO_3^- and NH_4^+ in BC treatment were found in weeks 4 (2.6 mg kg^{-1}) and 5 (285.9 mg kg^{-1}), respectively. Our findings indicated that transforming rice straw into biochar before soil application strongly reduces the decomposition and subsequently reduces CH_4 and CO_2 emissions from paddy soil. Furthermore, rice straw and biochar showed contrasting effects on NO_3^- and NH_4^+ availability that should be considered in fertilisation management.

Keywords: Methane emission, nitrogen, respiration, rice straw, rice straw-derived biochar, submerged soil

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