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Potential effects of earthworm activity on C and N dynamics in tropical paddy soil

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Earthworms are involved in key ecosystem processes and are generally considered important for sustainable crop production. However, their provision of essential ecosystem services and contribution to tropical soil carbon and nitrogen balance in rice-based agroecosystems are not yet completely understood. We carried out two microcosm experiments to quantify the impact of a tropical earthworm Pheretima sp. from the Philippines on C and N turnover in rice paddy soils. First one was conducted to understand the modulation impact of soil water saturation level and nitrogen fertilizer input intensity on C and N cycles. The second one focused on the importance of additional organic matter (rice straw) amendment on the earthworm modulation of mineralization in non-flooded conditions. We measured CO_2, CH_4 (Experiments 1 and 2) and N_2O evolution (Experiment 2) from rice paddy soil collected at the fields of the International Rice Research Institute (Philippines). Further we analysed changes in soil C and N content as well as nutrient loss via leaching induced by earthworms (Experiment 2).

Addition of earthworms resulted in the strong increase of CH_4 release under flooded conditions as well as after rice straw amendment. Compared to flooded conditions, earthworms suppressed the distinct CO_2 respiration maximum at intermediate soil water saturation levels. In the first few days after the experiment establishment (Experiment 1) intensive nitrogen application resulted in the suppression of CO_2 emission by earthworms at non-flooded soil conditions. However, at the longer term perspective addressed in the second experiment (30 days) earthworm activity rather increased average soil respiration under intensive fertilization or rice straw amendment. The lowest N_2O release rates were revealed in the microcosms with earthworm and straw treatments. The combined effect of N fertilizer and straw addition to microcosms resulted in the increased leachate volume due to earthworm bioturbation activity. The mean relative C loss with leaching was increased by earthworms under intensive fertilization and consequently resulting soil C content in the end of Experiment 2 decreased. N concentration in the leachate remained unaffected by earthworms although the remaining N content in soil with straw application and earthworm treatment was significantly higher than in the control.

Our results showed that the potential role of earthworms in C-stabilization is confined to moderately irrigated soils that allow high earthworm activity. Earthworm effects on C and N release under non-flooded conditions were largely modulated by the application of N fertilizer (urea) and by the amendment of rice straw. Our findings suggest that the presence of earthworms significantly affect C and N budgets in rice paddy soil, especially in the intensively managed non-flooded fields. In the short term perspective they sequester C and N loss from soil. However, in the longer term (ca. 30 days) this sequestration effect remains significant only for nitrogen under the straw application treatment.

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