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Water use efficiency and the net ecosystem C balance assessments from rice cultivation in Benin

COFFI LEONCE GEOFFROY SOSSA¹, B. JESSE NAAB¹, AUGUSTIN JUERGEN², SOULEYMANE
SANOGO³, O. LUC SINTONDI⁴, MATHIAS HOFFMANN²

¹West African Science Service Center on Climate Change and Adapted Land Use (WASCAL), Benin

²Leibniz-Centre for Agric. Landscape Res. (ZALF), Isotope Biogeochemistry and Gas Fluxes, Germany

³Université des Sciences, des Techniques et des Technologies de Bamako (USTTB), Lab. of Optics, Spectroscopy and Science of Atmosphere (LOSSA), Mali

⁴Université d'Abomey-Calavi, Inst. National de l'Eau, Benin

Abstract

The water use efficiency (WUE) and net ecosystem carbon (C) balance (NECB) are key indicators of agroecosystems, used to describe the trade-off between yield on the one hand, and required water and soil C loss/gain on the other hand. Considering the different farming practices, sustaining, or even increasing yields while improving water use and limiting carbon loss is therefore vital for sustainable agriculture. Here, we seek to assess the WUE and the NECB from rice cultivation as affected by different water management and N fertiliser rates in southern Benin. A field experiment was established from November 2022 to March 2023 at Koussin lélé, Cove district, using a split-plot experimental design. The main plots are different water management measures, which include continuous flooding (CF) and two thresholds (at 15 cm and 30 cm below surface) of alternate wetting and drying (AWD) irrigation (AWD15 and AWD25). The subplots are two rates of N fertiliser that include 90 kg ha⁻¹ (farmer's practice) and 120 kg ha⁻¹ (high amount of fertiliser). WUE and the NECB were assessed based on dynamic, manual closed chamber (A: 0.16 m²; V: 0.16 m³) measurements of evapotranspiration (ET), ecosystem respiration (Reco), and net ecosystem exchange (NEE), which were performed biweekly with a novel, low-cost ET, and CO₂ flux logger system. Measured CO₂ and ET fluxes were calculated using modular R scripts. The results showed that the agronomic WUE (yield (g)/ET (mm)) ranged from 1.63 g mm⁻¹ to 2.36 g mm⁻¹ and was highest under CF and AWD15 with N90 (statistically similar). All the treatments were small C sinks. The highest negative NECB (atmospheric sign convention) was recorded under CF with N120 (-30.98 g C m⁻²) whereas the NECB was recorded under AWD15 with N120 (6.28 g C m⁻²). The increase in negative NECB was in the order CFN90 > AWD15N90 > CFN120 > AWD25N90 > AWD25N120 > AWD15N120. In addition, the grain yield under CF and AWD15 are statistically similar. Therefore, we recommend adopting the AWD15 irrigation regime with an application rate of N 90 kg ha⁻¹ for sustainable irrigated rice production.

Keywords: N fertiliser, NECB, rice, water management, water use efficiency