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"Reconcile land system changes
with planetary health"

Sustainable fertilisation to reduce ghg emissions and increase rice yield in madagascar's highland lowlands

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Abstract

Rice yields in sub-Saharan Africa (SSA) are limited due to nutrient-poor soils and low fertiliser usage, averaging only 2.3 t ha^{-1}. Rice husk biochar has been reported to improve soil physicochemical properties, enhance soil fertility and potentially reduce greenhouse gas (GHG) emissions; however, its combined effects with chemical fertilisers on grain yield GHG emissions from nutrient-deficient lowlands in SSA remain poorly understood. To address this, we conducted on-farm trials by factorially combining two rates of biochar application (Biocharlow: 5 t ha^{-1} and Biocharhigh: 20 t ha^{-1}) with and without NPK (N:63.9 kg ha^{-1}; P:30 kg ha^{-1}; K:41.1 kg ha^{-1}) plus NPK alone and Ct (no biochar or fertiliser applied). Biochar was produced through a conventional method using rice husks and was characterised by a carbon content of 33.74 % and a nitrogen content of 0.48 %. Our results showed that the control had the lowest rice yield. Applying low and high rates of biochar without NPK increased rice yield by 1.6 and 1.1 times compared to the Ct, though both were still lower than yields with NPK alone. Notably, combining high-rate biochar with NPK increased yields by 1.2 to 1.1 times compared to NPK alone or with low biochar. Methane (CH) emissions did not differ significantly among treatments, although the control showed the lowest emissions, followed by low biochar, NPK, and their combination. The highest CH_4 emissions were observed with high biochar, both with and without NPK. Nitrous oxide (N_2O) emissions showed no significant differences across treatments, though a slight increase was noted with NPK use. While high biochar applications contributed to a greater overall global warming potential, differences were not statistically significant. Importantly, biochar combined with NPK reduced GHG emissions per unit grain yield by 7 % (high rate) and 12 % (low rate) compared to NPK alone. Without NPK, these reductions were 7 % and 20 %, respectively, compared to the control. Overall, integrating rice husk biochar with mineral fertiliser can improve rice yields and reduce GHG emissions per unit of production, offering a promising strategy toward more sustainable and climate-resilient rice farming systems.

Keywords: Methane, nitrous oxide, nutrient deficient soil, rice husk biochar, rice yield

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