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Predicting soil organic carbon sequestration and greenhouse gas mitigation potential from Bangladesh rice cropland - a spatial analysis

Khadiza begum (1), Matthias Kuhnert (1), Jagadeesh Yeluripati (2), Pete Smith (1), William Parton (3), and Stephen Ogle (3)

(1) Institute of Biological & Environmental Science, University of Aberdeen, 23 St Machar Drive, Aberdeen, AB24 3UU, UK, (2) The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK, (3) Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado, United States of America

Rice (Oryza sativa L.) is cultivated as a major crop in most Asian countries and rice production is expected to increase to meet the demand of a growing population. The assessment of greenhouse gas (GHG) emissions from paddy rice ecosystems is important to assess if there a significant potential for reducing GHG emissions. Because the sustainable use of the soil resources needs to be assessed over long time periods and across spatial scales, model approaches are useful tools to estimate GHG emissions and corresponding mitigation potentials. The biogeochemical model DayCent was applied to determine the mitigation potential for soil organic carbon sequestration (SOC), considering the impacts on the GHG emissions methane (CH4) and nitrous oxide (N2O), from double rice cropping systems in Bangladesh. The main goal in this study was to assess how alternative management, including alternate wetting and drying (AWD) instead of constant flooding, more residue return (15% residue instead of 5%), reduced tillage, manure application (instead of mineral fertilizer application), in a single or integrated approach would likely contribute to offset GHGs by increasing SOC and/ or by reducing GHG emissions. Spatially distributed data are used to simulate changes in SOC and GHG emissions for 64 districts in Bangladesh under different mitigation management over the period 1996 to 2015. The results showed that the application of manure can sequester twice the amount of SOC than under current farmer's practice. However, such practice reduces yield nearly by 50% of current yield. In contrast, changes in water management show neutral to slightly lower (<5% of current conditions) yields, while CH4 emissions reduced by 25% under this modification. SOC sequestration was not attained under these practices, which agrees to observations made in other studies. By calculating net GHG balance using global warming potentials over a 100 year time span (CO_2 eq. ha-1 yr-1), the best options among the selected mitigation scenarios were integrated management (AWD along with more residue incorporation, reduced tillage, manure and mineral N fertilizer application) followed by changes in the water management to AWD. Although CH4 and N2O emissions appeared to increase under integrated management, the SOC sequestration increases up to twice the baseline conditions and thereby reduces overall GHGs in most regions. Yield in two cropping seasons under these management practices varied by $\pm$15%. GHG emissions can be reduced by 40 teragrams (CO_2 eq. yr-1) under integrated management from Bangladesh rice soil, which is around 20% less than the emissions offset by manure addition but three times the management associated with AWD. Following integrated management practice it is possible to negate current total CH4 emitted from rice fields in Bangladesh.

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