Soil trace gas fluxes from secondary forest converted to small-scale vegetable farms on an Andosol soil

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The Philippines’ agriculture sector continues contributing to country-wide soil trace gas emissions; however, field-based estimation of emissions from this sector remains inadequate. While there’s a need to increase crop production to provide for a fast-increasing population, it is equally essential to reduce greenhouse gases (GHG) from agricultural production to protect the environment. A reliable assessment of soil GHG is a requisite to attain these, thus the present study. We conducted spatially replicated quantification of soil greenhouse gas fluxes, i.e. N₂O, CH₄, and CO₂, with monthly measurements from May 2018 to May 2019, as well as their soil controlling factors in nine plots of secondary forest and ten farms, all on comparable Andosol soil in Leyte Island, the Philippines. The management practices of these vegetable farms were those implemented by the farmers, and our measurements were carried out on these actual farm practices, reflecting their commonly varied fertilization rates (200 – 610 kg N ha⁻¹ cropping period⁻¹ with 2 – 3 cropping periods each year). Soil N₂O emissions from vegetable farms were larger than the forest (P ≤0.01) and were stimulated during the dry than the wet season (P ≤0.01). Its temporal variation was mainly driven by soil NO₃⁻ (r = 0.52, P ≤0.01). Large stocks of soil extractable NO₃⁻ in the top 50 cm (9250 ± 2830 mg N m⁻², mean ± SE) and 50 – 100 cm soil depth (11255 ± 5980 mg N m⁻²) supported the substantial soil N₂O emissions from these vegetable farms, which were larger than those from other agricultural areas in South East Asia on similar soil and climate. These small-scale vegetable farms had annual fluxes of 12.7 ± 2.6 kg N₂O–N, −1.1 ± 0.1 kg CH₄–C and 11.6 ± 0.7 Mg CO₂–C ha⁻¹ yr⁻¹, whereas the secondary forest as reference land use had 0.10 ± 0.02 kg N₂O–N, −2.0 ± 0.2 kg CH₄–C, and 8.2 ± 0.7 Mg CO₂–C ha⁻¹ yr⁻¹. The forest had larger soil CH₄ uptake than the vegetable farms (P ≤0.01). For the forest, CH₄ uptake was positively correlated with soil moisture (r = 0.60, P ≤0.01), suggesting diffusion limitation of atmospheric CH₄ into the soil and/or soil CH₄ production during high rainfall months. For the vegetable farms, CH₄ uptake was negatively correlated with both soil NO₃⁻ and NH₄⁺ (r = −0.46, P ≤0.01), suggesting CH₄ consumption enhanced by mineral N. Soil CO₂ emissions were higher in vegetable farms relative to the forest (P ≤0.01), reflecting the former’s reduced soil organic carbon stocks in the top 1 m (P ≤0.01) but compensated with regular
application of chicken manure (460 – 1940 kg C ha\(^{-1}\) cropping period\(^{-1}\)) as organic fertilizer. Our study expounded understanding on the extent of changes in soil GHG from an Andosol soil that underwent land-use conversion. Such data will be beneficial in developing sound management and policy strategies for reducing soil GHG fluxes from this economically vulnerable agricultural sector.