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Greenhouse Gas Emissions and Global Warming Potential of Traditional and Diversified Tropical Rice Rotation Systems including Impacts of Upland Crop Management Practices i.e. Mulching and Inter-crop Cultivation

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Paddy rice cultivation is increasingly challenged by irrigation water scarcity, while at the same time changes in demand (e.g. changes in diets or increasing demand for biofuels) will feed back on agricultural practices. These factors are changing traditional cropping patterns from flooded double-rice systems to the introduction of well-aerated upland crop systems in the dry season. Emissions of methane (CH4) are expected to decrease, while emissions of nitrous oxide (N2O) will increase and soil organic carbon (SOC) stocks will most likely be volatilized in the form of carbon dioxide (CO_2). We measured greenhouse gas (GHG) emissions at the International Rice Research Institute (IRRI) in the Philippines to provide a comparative assessment of the global warming potentials (GWP) as well as yield scaled GWPs of different crop rotations and to evaluate mitigation potentials or risks of new management practices i.e. mulching and inter-crop cultivation. New management practices of mulching and intercrop cultivation will also have the potential to change SOC dynamics, thus can play the key role in contributing to the GWP of upland cropping systems.

To present, more than three years of continuous measurement data of CH4 and N2O emissions in double-rice cropping (R-R) and paddy rice rotations diversified with either maize (R-M) or aerobic rice (R-A) in upland cultivation have been collected. Introduction of upland crops in the dry season reduced irrigation water use and CH4 emissions by 66-81% and 95-99%, respectively. Moreover, for practices including upland crops, CH4 emissions in the subsequent wet season with paddy rice were reduced by 54-60%. Although annual N2O emissions increased twice- to threefold in the diversified systems, the strong reduction of CH4 led to a significantly lower ($p<0.05$) annual GWP (CH4+ N2O) as compared to the traditional double-rice cropping system. Measurements of soil organic carbon contents before and three years after introduction of upland crop rotations indicated a SOC loss for the R-M system, while for the other systems SOC stocks were unaffected. This trend for R-M systems needs to be followed since it has significant consequences not only for the GWP balance but also with regard to soil fertility.

New upland crop management practices where first implemented during land-preparation for dry season (July) 2015 where i) 6t/ha rice straw was returned to the field and incorporated into soil as mulch treatment and ii) mungbean was grown as a cover-crop between dry and wet season in addition to the rice straw application. The input of organic material led to higher methanogenic substrate availability during the following wet season. GHG measurements for upland cropping systems (R-M and R-A) indicate increased CH4 and N2O emissions with mulching and inter-crop cultivation when compared to a control treatment. Subsequent measurements will be necessary to further quantify and assess the mitigation potentials or risks of new management practices.

Nevertheless, regarding a future increase of water scarcity it can be expected that mixed lowland-upland systems will expand in SE Asia as water requirements were cut by more than half in both rotation systems with upland crops.