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Assessment of Water and Nitrogen Limitations to Paddy Rice Performance Using N-15 and C-13 Stable Isotopes

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Abstract

Considerable research regarding impact of land use intensification on erosion and runoff production has been carried out in various tropical mountainous regions in South East Asia. However, little is known about the impact of resulting sediment contribution from eroded upland fields, with intensive agricultural activities, to lower paddy fields which produce up to two rice crops a year. Increase in agricultural productivity to match the people's needs was mainly achieved by the clearance of upland forests for the cultivation of cash crops like maize and cassava. These procedures have a large impact through erosion and nutrient fluxes downstream. Depending on the availability of rain and irrigation water, rice paddies are cultivated either once in the rainy season or twice, by supplemental irrigation water. Overall crop productivity of paddies is hampered by water shortages, mainly during the first season. In order to assess impacts of seasonal conditions, fertilisers and uplands-sediments on the lowlands crop, Isotope Ratio Mass Spectrometry (IRMS) was used to examine the plant and soil composition of nitrogen (^{15}N) and carbon (^{13}C) stable isotopes. Analysis performed during this study proved the hypothesis that the isotopic composition of rice grains shows clear relations to growing conditions, particularly for ^{13}C. The relative extents and proportions of the limitations on crop performance caused by lack of nitrogen and water shortages could be shown. Still, depending on the position of paddies across the lowlands (along a cascade) the trends illustrated the varying allocation of water and resources like nutrients, in particular nitrogen. Close to the channels, nitrogen and water stresses were lowest in the rice grains according to stable isotope discrimination method, with a clear increase in all treatments and in both seasons towards the middle-lower parts of the cascades. Total nitrogen of soil samples, however, showed an accumulation until the middle of the cascade and decreased thereafter. Therefore water seems to be strongly influencing nutrient uptake in the cascades. These results show the importance of the use of stable isotopes in order to understand the impact of erosion sedimentation and nutrient fluxes on catchment scale influencing its crop productivity.

Keywords: Crop performance, rice, sedimentation, spatial variability, stable isotopes

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