

関東地方の水田における大気沈着および灌漑水由来の正味の窒素インプット Net nitrogen input through the atmospheric deposition and irrigation water at a paddy field in central Japan

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The aim of the present study was to evaluate the net nitrogen input through the atmospheric deposition and irrigation water at a paddy field for single cropping of paddy rice in central Japan, where the wet deposition and exchanges of gases and particles (as the difference between the dry deposition and emissions) were measured for the atmospheric deposition. Target species of reactive nitrogen (Nr) were ammonium (NH_4^+) and nitrate (NO_3^-) for the wet deposition, ammonia (NH_3), nitric acid (HNO_3), and nitrous acid (HNO_2) as gases and particulate ammonium (pNH_4) and nitrate (pNO_3) as particles for the atmosphere-rice paddy exchange, and NH_4^+ , NO_3^- , and organic nitrogen (OrgN) for the irrigation water.

Monitoring of those processes were conducted for three years from September 2010 to September 2013 at a paddy field in central Japan which was devoted for an experimental site of free-air CO_2 enrichment (FACE). Rainwater samples were collected weekly and the wet deposition was calculated using the Nr concentration and the collected volume of water. The air concentrations of Nr were measured using a filter-pack method at two heights of 6 m and 2 m above the ground surface on a weekly mean basis with day/night separation. A filter-pack consisted of five filter holders to collect the target Nr. The diffusion velocity was calculated using the micrometeorological and eddy covariance data in half-hourly basis and then the weekly-mean values in the daytime and nighttime were calculated. The exchange fluxes were expressed as the product of the difference in air concentration between the two heights multiplied by the diffusion velocity. Cumulative exchange fluxes were also calculated based on the weekly mean exchange fluxes. The flow rate and quality of irrigation water was monitored in the cropping seasons in 2011, 2012, and 2013 at a bay in the paddy field. Each of two inlets and one outlet at the bay was equipped with a flow gaging weir and the water flow was measured continuously. Water was sampled at the weirs every week in principle and the concentrations of Nr were measured, where OrgN was calculated as the difference between the total nitrogen and the sum of NH_4^+ and NO_3^- . The inflow and outflow of Nr by irrigation were then calculated using the flow rate and concentration data.

Annual wet deposition of Nr was 9.5, 8.6, and 5.9 $\text{kg N ha}^{-1} \text{ yr}^{-1}$ for the first, second, and third years, respectively, where NH_4^+ and NO_3^- showed similar contributions quantitatively. In addition, the contribution of OrgN was negligible in the wet deposition. Annual exchanges of Nr between the paddy field and the atmosphere were estimated to around 2-3 $\text{kg N ha}^{-1} \text{ yr}^{-1}$, where a certain extent of the dry deposition was counterbalanced by the emissions. Ammonia was the most dominant Nr among the target species in the atmosphere. Ammonia also showed the largest dry deposition among Nr; however, a large part of which was canceled by the emissions of NH_3 from the paddy field. The differences between the inflow and outflow for the irrigation water were 10.7, 8.8, and 6.7 $\text{kg N ha}^{-1} \text{ yr}^{-1}$ for the first, second, and third years, respectively, where OrgN accounted for 30-40% of Nr. In total, the net input of Nr to the paddy field through the atmospheric deposition and irrigation water was estimated to approximately 20 $\text{kg N ha}^{-1} \text{ yr}^{-1}$ which corresponds to approximately 30% of a standard application rate of nitrogen fertilizers in this area. However, it is desired that the following processes are also incorporated to complete the evaluation of the nitrogen balance: the biological nitrogen fixation and the dry deposition of nitrogen oxides (nitrogen monoxide and nitrogen dioxide) as inputs; and the denitrification (nitrogen monoxide, nitrous oxide, and dinitrogen) and the leaching of Nr to the groundwater as outputs.

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