Effect of micrometeorological conditions varied with rice growth on stable isotope ratios of hydrogen and oxygen of paddy water

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Evaporation and transpiration from a paddy field are very important for regional water balance especially in Monsoon Asia. These vapor fluxes are often integrated and called evapotranspiration; nevertheless they are essentially different processes. One of the reasons is the difficulty of determining these fluxes separately by micrometeorological methods such as eddy correlation. Isotope hydrological techniques would have a possibility to divide evapotranspiration into evaporation and transpiration, because only evaporation can affect the isotope composition of ponded water. In this study, we investigated stable isotope ratios of paddy water as well as micrometeorological conditions under and over rice canopy, and examined the relationship between the both.

Field observation was performed at a rectangular lot (100 m long and 54 m wide) of paddy field located in Mase, Tsukuba, Japan. We collected paddy water samples (i.e. irrigation water, drain water, and ponded water) once or twice a week during the cultivation period, from April to August 2004. Diurnal variation of the isotope composition was also investigated on May 29. Rainwater was accumulated in a precipitation sampler equipped with a simple sealing device, and collected by each storm event. Stable isotope ratios of hydrogen and oxygen were determined with a dual-inlet isotope ratio mass spectrometer at the University of Tsukuba. Components of water balance of the paddy field (i.e. the amount of rainfall, irrigation, evapotranspiration, drainage, and the depth of ponded water) were automatically measured and recorded. The parameters related to rice growth such as LAI and plant height were investigated periodically, as well as micrometeorological conditions such as wind velocity and air temperature under and over the rice canopy.

Stable isotope ratios of ponded water gradually increased during downstream water movement due to evaporative isotope fractionation. The isotope ratios at each sampling point generally decreased with time, while irrigation water showed nearly constant values throughout the cultivation. Therefore, the differences of the isotope ratios between irrigation and drainage were maximal after the transplanting of rice and then reduced with time, suggesting the decrease of evaporative fractionation caused by the growth of rice canopy. Just after heavy rain on May 20 and 21, however, most of ponded water samples indicated stable isotope ratios similar to that of rainwater. The ranges of diurnal variation of the isotope ratios of hydrogen and oxygen reached 8 and 1.8 per mil, respectively.

The height of rice community, which affects the proportion of evaporation and transpiration from paddy field, grew linearly from 0.1 m at the transplanting to 0.9 m in August. This growth gradually altered the micrometeorological condition in the rice community (measured at a height of 0.15 m from the ground surface) relative to the condition out of the community (measured at a height of 1.2 m). The ratio of wind velocity, inside of the community to the outside, rapidly decreased from 0.5 at the transplanting to 0.1 in late June, and then became stable. Similarly changed the ratio of air temperature, from 1.05 to 0.95 in mid-July. These results are in consistent with the decrease of ponded water evaporation following the rice growth.

The result of the study suggest that the stable isotope ratios of ponded water are strongly related to evaporative loss, and have a possibility to separate the evaporation from evapotranspiration, determined by another method. In future study, the development of the method to remove or evaluate the influences of rainfall and diurnal fractionation would be needed.