Partitioning Soil Evaporation and Transpiration for Plant Water Use Efficiency using Hydrometric Measurements and Stable Isotope Techniques

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Abstract

Today, there are 925 million people in the world suffer from chronic hunger, stated Food and Agriculture Organization (FAO, 2010). People depend on plants for food and water is the major environmental factor limiting plants to growth. Best practice agriculture is the key to overcome this problem through improvement of water use efficiency in irrigated lands. Therefore, knowledge of the water fluxes within the soil-vegetation system is crucial. Many studies have been carried on to quantify these fluxes by plants but it encounters difficulties in quantifying the relative contribution of evaporation and transpiration. The uses of environmental isotopes with their unique attributes present a new and important technique to enable fluxes tracing within soil-plant-atmosphere continuum (SPAC) system (Kendall and McDonnell, 1998; Mook, 2000; Shichun, et al., 2010; Wenninger, et al., 2010). Moreover, isotopes can be used to determine the portions of evaporation and transpiration (Yoshimura, et al., 2006) using isotopic mass balance calculations (Robertson and Gazis, 2006; Saraiva, 2010; Wenninger, et al., 2010).

This study has used a combination of hydrometric measurements and stable isotopes techniques in a grassland lysimeter located in UNESCO-IHE, Delft, the Netherlands. The actual evaporation is calculated using the water balance, the Penman-Monteith, the numerical modelling and the isotopes mass balance method while partitioning of soil evaporation and transpiration has been carried out using the isotopes mass balance method and with taking into account the interception value. Lysimeter set-up has been equipped with soil moisture sensors, a percolation device, a weighing balance, meteorological recorder and Rhizon samplers to abstract soil water samples.

Total evaporation during simulation period is 305.5 mm/T calculated from HYDRUS-1D whereas total evaporation from Penman-Monteith, isotope mass balance, and water balance are 262.4 mm/T, 237.3 mm/T and 243.1 mm/T respectively. The average soil evaporation is 0.35 mm/d, interception is 0.3 mm/d and transpiration is 2.25 mm/d calculated from the isotope mass balance. Isotope mass balance analysis revealed that the isotope mass balance is a useful tool to partition evaporation fluxes. With the revealed of plant transpiration, irrigation systems can be applied effectively particularly in water scarce areas.

Keywords: *water use efficiency, evaporation, transpiration, stable isotopes, numerical modelling*