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Hydrological processes and water flux quantification in agricultural fields under different tillage and irrigation systems using water stable isotopes

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Sustainable agriculture should be based on management practices that improve resource usage efficiency and minimize harmful impacts on the environment while maintaining and stabilizing crop production. Both tillage and irrigation can have a great influence on hydrological processes within agroecosystems. However, it remains difficult to directly assess the effect of practices on water fluxes which has been mainly indirectly quantified by complex numerical modelling methods in the past. Therefore, the objective of the study was to use a space for time concept and measure oxygen and hydrogen isotopes ($\delta^{18}O$, $\delta^{2}H$) in the pore water of soil profiles as well as moisture contents for quantifying the soil water balance and fluxes. Covering all combinations, soil profiles and isotope analysis was performed for 16 sites planted with winter wheat and managed with different tillage (conventional tillage (CT), reduced tillage (RT), minimal tillage (MT), and no-tillage (NT)) and irrigation systems (hose reel boom irrigation with nozzles (BI), sprinkler irrigation (SI), drip irrigation (DI) and no irrigation (NI)). The results indicated that the more intense the tillage, the lower the water content. Among the irrigation systems, DI had the highest average water content. Tracing the minimum in the isotopic composition of the pores water within the depth profiles showed a deeper percolation of water in the CT fields, which indicates higher water flow velocity. Considering both water content and differences in water flow velocities resulted in water fluxes ranging from 90 to 151 mm yr^{-1}. The losses due to evapotranspiration varied between 57 and 80%. The resulting evapotranspiration within tillage and irrigation variants decreased in the order RT>CT≈MT>NT, and SI>BI>DI>NI. Thus, the method revealed that the lower water content in CT fields is a consequence of deeper water infiltration. Moreover, irrigation water contributed mostly to evapotranspiration, and drip irrigation showed the lowest evapotranspiration losses among irrigation systems. This study demonstrated that water stable isotopes can be used as indicators and are a promising method to quantify water fluxes in agricultural fields with great potential for evaluating management practices.