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Partitioning evapotranspiration into transpiration and evaporation by use of isotope balance calculation

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Knowledge and quantification of water fluxes within the soil-vegetation-atmosphere continuum is fundamental to understand ecohydrological systems. It is also essential to further develop water management practices and irrigation systems in times of increasing needs for water and rising water scarcity. A major component in this regard is evapotranspiration (ET) as it links the energy balance and the water balance. Evapotranspiration can be fractionated into productive water fluxes through plants' stomata (transpiration) and non-productive water loss from soil surface (evaporation). Determination and understanding of factors influencing this ratio are assumed to help improving water use efficiency through best management practices in agriculture, especially in water limited environments. Aim of this study was to adapt a stable isotope mass balance method for determining evapotranspiration and its components transpiration and evaporation for soybeans under natural conditions.

The study site was in Groß-Enzersdorf, east of Vienna, Austria (48°12' N, 16°34' E; 157 m elevation a.s.l.). The study period covered the vegetation period of soybeans in 2019. Crop evapotranspiration was determined using a weighing lysimeter with 1.8 m diameter. For the fractionation, a stable isotope mass balance method from literature was adapted and further developed for soybeans under natural (stressed) climatic conditions. The underlying principle of isotope fractionation is that different physical properties of naturally occurring stable isotopes in water cause shifts in the isotopic composition due to evaporation. Therefore, evaporation causes enrichment of heavier stable isotopes in the near surface soil water, whereas water uptake by plant roots does not cause considerable partitioning in soil water. This allows determination of both fractions, assuming all other water balance components are known. Soil samples for the stable isotope mass balance were taken near a weighing lysimeter (1.8 m diameter). Evapotranspiration determined by the lysimeter provided the basis for the mass balance fractionation calculations. Monitoring throughout the soybeans vegetation period included weekly analyses of isotopic composition of soil samples, measurements of water content over the soil profile in 10 cm steps down to 80 cm, weather data, and crop growing stages.

Results reveal a plausible course of soybean evapotranspiration and its components. The preliminary designed method of soil water sampling could be adequately adapted to determine

representative isotopic soil profiles for water balance determination under the given conditions. Water extraction from the soil samples worked well under moist as well as very dry soil conditions. Further data analysis was done to assess applicability of the modified method to determine fractionation ratios for different plant development stages. The available results encourage further experiments to test and investigate the versatility of this method with respect to different soil cultivation methods for a water use efficiency review.