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Use of water stable isotopes (18O) for Hydraulic Lift characterization

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Hydraulic Lift (HL) is defined as the nocturnal redistribution by plant roots of soil water from wetter (and in general deeper) layers into dryer (and in general shallower) layers. HL has been observed for a number of plant species but the volumes of water involved in this phenomenon remain controversial: very low according to some, or enough to impact the continental water cycle, by reducing soil water deficit and therefore enhancing the evapotranspiration. In this study, HL was analysed by mean of stable isotopes measurements (18O) under semi-controlled conditions. Two continuously weighted rhizotrons (dimensions 1.60 m * 1.00 m * 0.20 m) of disturbed soil (65 % loam, 20% silt) were sown with tall fescue (Festuca Arundinacea) and placed in a glasshouse in Lusignan (INRA, France). Soil water tension, volumetric content and soil temperature were continuously monitored from the surface down to 1.30 m and root development was measured during the experiment. Supply of water was exclusively performed from a reservoir located at the bottom of each rhizotron (acting as a water table). On two occasions, the reservoir water was enriched with heavy stable isotopes. Root water uptake induces no isotopic discrimination against heavy isotopes of water. By extracting water (air vacuum distillation) from fescue tillers, we could determine the isotopic composition of total root water uptake. Under the specific conditions of the rhizotron experiments, it was then possible to determine the origin of root water uptake in the soil. The isotopic composition of leaf water depends, amongst other things, on that of the tiller water (i.e. leaf input water) and depends on plant transpiration flux intensity. Before and after labeling the reservoir water, tillers, leaves and soil samples (from the surface down to 1.30 m) were collected for isotopic and leaf water potential measurements during 34 hours. From the strong daily disparities between leaf and tiller isotopic compositions, it was inferred that tall fescue extracted water in deep soil layers under both strong (day) and weak (night) transpiration fluxes. The influence of HL on soil water isotopic composition was not observed. In a second labeling experiment however, an increase of the soil water isotopic composition between depths 0.10 m and 0.25 m revealed that less than 5% of water in that particular layer came from deep layers.