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Ecohydrological interactions between soil and trees in Alpine apple orchards

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Tracer-based investigations of water exchanges between soil and trees in natural forested catchments are receiving relevant attention in modern ecohydrology. However, the interactions between tree water use and the hydrological cycle in agricultural environments are still poorly understood. In this work, we use stable isotopes of water (2H and 18O) and electric conductivity as tracers to improve our understanding of the functional interrelations between water generating surface runoff and recharging groundwater, and water taken up by apple trees (Malus domestica, cv. 'Pinova') in an Alpine valley in South Tyrol, Northern Italy. From April to October 2015 we monitored two orchards approximately of the same size (roughly 400 m2) and soil texture (silt loam) located in a flat area at different distance from the Adige/Etsch River (50 m vs. 450 m). We have addressed the following questions: i) at which soil depth do apple trees take up water? ii) do apple trees take up water from shallow groundwater? iii) are there differences in the isotopic composition of the water fluxes between the two sites?

Samples for isotopic analysis were taken approximately fortnightly from the river, two groundwater wells close to each field, mobile soil water (from suction cups at 25 cm and 50 cm), open area precipitation, throughfall, irrigation and sap (through a portable pressure bomb). Tightly-bound soil water was also cryogenically extracted from samples taken every 10 cm from 60 cm-long soil cores taken at three locations for each field on one occasion in mid-summer. Ancillary measurements were electrical conductivity of all water sources except for sap. In addition to meteorological and discharge data, soil moisture was continuously measured at 10 cm and 50 cm in three locations, and sap flow on three trees, for each field.

Preliminary results show that two water pools with distinct isotopic signature exist: i) river water, groundwater and irrigation water show values relatively depleted and consistent with the local meteoric water line, whereas ii) soil water and sap have values more enriched and deviated from the meteoric line. Soil water shows a clear evaporation signal that decreases with increasing soil depth. Sap isotopic data are inconsistent with groundwater data but reflect well soil water data in the first 40 cm. This suggests that apple trees absorb a mixture of rainfall and irrigation water which undergo partial evaporation in the shallow soil layer. Water table varies between 40 cm and 140 cm making groundwater not easily intercepted by tree roots, consistently with the small root apparatus of the apple trees grafted on M9 rootstocks. Results reveal also a marked intra-field spatial variability in the isotopic composition of soil water, and significant differences between the two fields, with the one close to the river showing significantly more depleted values compared to the one farther form the river. This difference, which is reflected by sap isotopic composition in summer, is likely related to the different radiation that hits the two fields, due to the shading effect played by steep slopes on the orchard closer to the river.