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On the stability of the relationship between reference evapotranspiration and single tree transpiration: test and validation over several irrigated tree orchards

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The present work aims to develop a simple approach relating normalized daily sap flow (per unit of leaf area) and daily ET0 (mm/day) calculated by two methods: FAO-Penman-Monteith (FAO-PM) and Hargreaves-Samani (HARG). The data sets used for developing this approach are taken from three experimental sites (olive trees, cv. "Oleaeuropaea L.", olive trees, cv. "Arbequino" and citrus trees cv. "Clementine Afourar") conducted in the Tensift region around Marrakech, Morocco and one experimental site (pecan orchard, cv. "Caryaillinoinensis, Wangenh. K. Koch") conducted in the Yaqui Valley, northwest of Mexico).
The results showed that the normalized daily sap flow (volume of transpired water per unit of leaf area) was linearly correlated with ET0 (mm per day) calculated by FAO-PM method. The coefficient of determination (R2) and the slope of this linear regression varied between 0.71 and 0.97 and between 0.30 and 0.35, respectively, depending on the type of orchards. For HARG method, the relationship between both terms is also linear but with less accuracy (R2 =0.7) as expected due to the underestimation of ET0 by this method. Afterward, the validation of the developed linear relationship was performed over an olive orchard ("Oleaeuropaea L.") where the measurements of sap flow were available for another (2004) cropping season. The scatter plot between the normalized measured and estimated sap flow based on FAO-PM method reveals a very good agreement (slope = 1, with R2 = 0.83 and RMSE=0.14 L/m2 leaf area). However, for the estimation of normalized sap flow based on HARG method, the correlation is more scattered with some underestimation (5%). A further validation wasperformed using the measurements of evapotranspiration (ET) by eddy correlation system and the results showed that the correlation between normalized measured ET and estimated normalized sap flow is best when using FAO-PM method (RMSE=0.33 L/m2 leaf area) for estimating ET0 than when using HARG method (RMSE= 0.51 L/m2 leaf area).
Finally, the performance of the developed approach was compared to the traditional dual crop coefficient scheme for estimating plant transpiration. Cross-comparison of these two approaches with the measurements data gave satisfactory results with an average value of RMSE equal to about 0.37 mm/day for both approaches.