A comparison of modelling solutions for transpiration and yield of olive orchards

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Crop models usually calculate biomass accumulation (carbon assimilation) by making use of simple but robust relationships between the assimilation of C and a related process. These relationships are typically the Radiation Use Efficiency (RUE) or the Water Use Efficiency (WUE). A "potential rate" of assimilation is found, then this rate is reduced by coefficients representing the effect of stressors (water stress, light, temperature..).

OliveCan is a RUE-based olive model, which water stress effect is simulated by applying a reduction coefficient based on the ratio actual/potential transpiration to the biomass produced. The limits of this approach are related mainly to: a) the transpiration efficiency, typically invariable at instant level, have been demonstrated to be higher in stressed trees on daily and seasonal temporal scales (Villalobos et al., 2012, Roccuzzo et al, 2014); b) under localized irrigation, the definition of tree water status is decoupled to the average soil water content, and the water uptake from the wet and dry soil must be calculated separately to implement a water balance; and c) the photosynthesis rate under different air CO_2 concentration (like those expected in the future) cannot be reliably calculated with a RUE approach.

These limitations were solved with a major redesign of the OliveCan modelling structure. The new OliveCan 2.0 has the following characteristics: 1) photosynthesis is calculated starting with the complete Farquhar model; 2)the leaf area is distributed real-time between sun and shade categories; 3) instead of reducing the "potential" assimilation by a water stress function, the stomatal conductance is directly calculated from leaf water potential (Tuzet et al, 2003). The assimilation and transpiration are calculated with the conductance that satisfies the balance; 4) instead of calculating a demand (atmosphere and leaves) and a supply (roots and soil), the water movement through the plant is now simulated with a SPAC model, like a complex electric circuit, driven by water potential and resistances; 5) two compartments of the soil (irrigated and non-irrigated) wired in parallel (each one with a water potential, a root density, a temperature, all distributed over a depth profile) contribute together to the flux. A third soil compartment hosts the roots of the cover crop when present; 6) root conductance is calculated as a function of soil temperature.

OliveCan 2.0 is operative and under testing; the model has demonstrated to overcome the limitations of the previous OliveCan, and to be an improved tool for solving olive growing problems, and to better account for the effects of extreme meteorological events.