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Ecosystem-scale water use efficiency of a semi-arid pine forest: A key to high carbon sink in dry conditions?

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A 40 years old afforestation system under semi-arid conditions (long-term mean annual precipitation 280 mm) showed unexpected carbon sink strength (up to 3.5 t C ha^{-1} during the 5 years study period). Water and carbon exchange declined to near zero during the $\sim$6 months rainless period (ecosystem respiration $<$0.005 mg C m^{-2} s^{-1}), but with CO_2 uptake spikes after sunrise even when volumetric soil moisture content (top 10 cm) was down to 3%, vapor pressure deficit, D, was above 4 kPa and sensible heat flux reached daily maximum as high as 800 W m^{-2}. Bowen ratios of up to 16 reflected low stomatal conductance and rates of evapotranspiration during the dry season. We estimated GPP/T, (W, the ratio of gross primary productivity over canopy transpiration) that could be linked to plant physiology and observed high values reaching $\sim$4 mg C g H_2O^{-1} in the wet season. In the dry season, W was reduced because T was suppressed less than GPP, probably due to the high D values. We hypothesize that key factors in the success of this afforestation system is its high W, allowing it to maximize productivity in the wet season with limited precipitation, and the ability to maintain continuous carbon and water exchange throughout the year, allowing, in turn, rapid response to short-term environmental changes and to the onset of the short wet season. Characteristics of carbon, water and energy exchange of forest ecosystem in dry regions may become relevant to regions that may undergo drying trends according to future climate change scenarios, such as the Mediterranean basin.