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Energy fluxes in oil palm plantations as affected by water storage in the trunk

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Oil palm is increasingly expanding, particularly in Indonesia, but information on water and energy fluxes in oil palm plantations is still very limited and on how those are affected by environmental conditions or oil palm age. Using the eddy covariance technique, we studied turbulent fluxes of sensible (H) and latent (LE) heat and gross primary production (GPP) for 8 months each in a young oil palm plantation (1-year old) and subsequently in a mature plantation (12-year old) in Jambi Province, Sumatra, Indonesia. We measured transpiration (T) simultaneously using a sap flux technique. The energy budget was dominated by LE in both plantations, particularly in the mature one, where it represented up to 70% of the available energy. In the young oil palm plantation, evapotranspiration (ET) was significantly reduced and H fluxes were higher. This affected the Bowen ratio, defined as the ratio of H and LE, which was higher in the 1-year old plantation (0.67 ± 0.33), where it remained constant during the day, than in the mature plantation (0.14 ± 0.09), where it varied considerably over the day, suggesting that water accumulated inside the canopy. Using the Community Land Model (CLM), a process based land surface model that has been adapted to oil palm functional traits (i.e. CLM-Palm), we investigated the contribution of different water sources to the measured fluxes. CLM-Palm differentiates leaf and stem surfaces in modelling water interception and is therefore able to diagnose the fraction of dry leaves that contribute to T and the wet fraction of all vegetation surfaces (leaf and stem) that contributes to evaporation. Results from our simulations strengthen our hypothesis of significant contribution of canopy evaporation to ET. As observed in the field, water accumulates inside the canopy in the mature plantation in oil palm trunk surfaces including epiphytes, creating water reservoirs in the trunk, which potentially contribute to ET when they evaporate. The decoupling between GPP and T in the morning and the early decreases of both fluxes at midday suggest the existence of internal water storage mechanisms in oil palms both in the leaves and in the stem, which delayed the detection of water movement at the leaf petioles. The combination of our measured data with the model simulations suggest the existence of both external and internal trunk water storage mechanisms in mature oil palms contributing to ecosystem water fluxes. Oil palm plantations can lead to surface warming at early stages of development, but further assessments should be performed at landscape level to understand the climatic feedbacks of oil palm expansion.