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Water budget and the consequent canopy duration period in a teak plantation in a dry tropical region

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A soil-plant-air continuum multilayer model was used to numerically simulate canopy net assimilation (A_n), evapotranspiration (ET), and soil moisture in a deciduous teak plantation in a dry tropical climate of northern Thailand to examine the influence of soil drought on A_n. The timings of leaf flush and the end of the canopy duration period (CDP) were also investigated from the perspective of the temporal positive carbon gain. Two numerical experiments with different seasonal patterns of leaf area index (LAI) were carried out using above-canopy hydrometeorological data as input data. The first experiment involved seasonally varying LAI estimated based on time-series of radiative transmittance through the canopy, and the second experiment applied an annually constant LAI. The first simulation captured the measured seasonal changes in soil surface moisture; the simulated transpiration agreed with seasonal changes in heat pulse velocity, corresponding to the water use of individual trees, and the simulated An became slightly negative. However, in the second simulation, A_n became negative in the dry season because the decline in stomatal conductance due to severe soil drought limited the assimilation, and the simultaneous increase in leaf temperature increased dark respiration. Thus, these experiments revealed that the leaflessness in the dry season is reasonable for carbon gain and emphasized the unfavorable soil water status for carbon gain in the dry season. Examining the duration of positive A_n (DPA) in the second simulation showed that the start of the longest DPA (LDPA) in a year approached the timing of leaf flush in the teak plantation after the spring equinox. On the other hand, the end appeared earlier than that of all CDPs. This result is consistent with the sap flow stopping earlier than the complete leaf fall, implying that the carbon assimilation period ends before the completion of defoliation. The model sensitivity analysis in the second simulation suggests that a smaller LAI and slower maximum rate of carboxylation likely extend the LDPA because soil water from the surface to rooting depth is maintained longer at levels adequate for carbon gain by decreased canopy transpiration. The experiments also suggest that lower soil hydraulic conductivity and deeper rooting depth can postpone the end of the LDPA by increasing soil water retention and the soil water capacity, respectively. These hypotheses will be verified based on observations.

Keywords: canopy dyration period, carbon gain, dry tropical region, soil-plant-air continuum system, teak plantation, water budget