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Tracing the complementary and competitive water use patterns in a *Theobroma cacao* (cocoa) agroforestry system: A stable isotope approach

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In cocoa agroforesty systems, shade trees are used to create climate conditions that benefit cocoa growth and survival. However, the benefits may be offset by competition between shade trees and cocoa for water, especially in a changing climate. Here we use stable isotope tracers to quantify the patterns and depths of water uptake among shade timber trees, cocoa, and banana for a tropical agroforestry system in Trinidad. Rainfall was collected from August 2021 to September 2023. Three field campaigns were carried out at an upslope and downslope location representing different hydro-climatological conditions and at different times in the crop cycle. During each campaign and at each slope position, soil was collected from three pits at depths of 5, 15, 25, 50 and 75 cm below the surface, while up to 10 xylem cores were collected from the different plant species. Additional soil texture and soil moisture data were also collected. Cryogenic vacuum extraction was used to extract water from the soil and vegetation samples, while an Elementar Isoprime isotope ratio mass spectrometer was used to determine the δ^2H and δ^{18}O of the extracted water. These data were subsequently used for MixSIAR endmember mixing modelling. Our results suggest that cocoa and banana plants primarily use shallow soil water (0 – 10 cm below the surface), while shade and timber trees like Immortelle (*Erythrina poeppigiana*) and Cedar (*Cedrela odorata*) use water from deeper sources (20 – 50 cm below the surface). Spatially, plants located in upslope areas appear to use water from slightly deeper soil depths than downslope locations. Soils in the valley bottom were also wetter and had relatively higher clay content. This study indicates that shade trees do not compete with cocoa for water; however, bananas likely compete with cocoa making managing that co-cropping important.