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Using functional traits to assess crop-environment interactions in agroforestry systems

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Selecting crops that express certain reproductive, leaf, and root traits has led to diverse crop domestication syndromes. However, scientific and informal on-farm research has primarily focused on understanding and managing linkages between only certain traits and yield. There is strong evidence suggesting that leaf functional traits—i.e., the morphological (e.g., specific leaf area [SLA]), physiological (e.g., photosynthesis), and chemical (e.g., leaf nitrogen (N) concentrations) traits of plants—have also been influenced by domestication, and reflect trade-offs and constraints among aspects of crop biology and agroecosystem environmental conditions. Yet, our understanding of how agroforestry systems influence trait expression and relationships remains limited. We measured nine morphological (thickness, area, SLA), physiological (maximum photosynthetic rates, stomatal conductance, and water-use efficiency [WUE]) and chemical traits (leaf carbon (C) and N concentrations, C:N ratios), on six cultivars grown in two clonal gardens with distinct environmental characteristics (i.e., a "Mild dry season" with near-optimal cacao growing conditions, and a "Harsh dry season" site with sub-optimal conditions). Genotype x Environment interactions were detectable in leaf functional trait expression, though these interactions varied strongly with the group of traits being evaluated; morphological traits varied widely among clones but these differences were robust across sites, while physiological and chemical traits significantly differed between clones, though inter-clonal differences varied depending on sites. Specifically, SLA increased with the clone productivity potential at both sites, while the least productive clones exhibited higher trait variation with a given site. Our results suggest that evaluating functional trait variation informs our understanding of Genotype x Environment interactions in crops widely cultivated in agroforestry systems. These results also suggest that integrating theory and techniques from functional trait ecology into agroforestry management design and crop selection, can contribute to optimizing agroforestry production under environmental constraints.