Elucidating Drought-Tolerance Mechanisms in Plant Roots through 1H NMR Metabolomics in Parallel with MALDI-MS, and NanoSIMS Imaging Techniques

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As direct mediators between plants and soil, roots play an important role in metabolic responses to environmental stresses such as drought, yet these responses are vastly uncharacterized on a plant-specific level, especially for co-occurring species. Here, we aim to examine the effects of drought on root metabolic profiles and carbon allocation pathways of three tropical rainforest species by combining cutting-edge metabolomic and imaging technologies in an in situ position-specific 13 C-pyruvate root-labeling experiment. Further, washed (rhizosphere-depleted) and unwashed roots were examined to test the impact of microbial presence on root metabolic pathways. Drought had a species-specific impact on the metabolic profiles and spatial distribution in Piper sp. and Hibiscus rosa sinensis roots, signifying different defense mechanisms; Piper sp. enhanced root structural defense via recalcitrant compounds including lignin, while H. rosa sinensis enhanced biochemical defense via secretion of antioxidants and fatty acids. In contrast, Clitoria fairchildiana , a legume tree, was not influenced as much by drought but rather by rhizosphere presence where carbohydrate storage was enhanced, indicating a close association with symbiotic microbes. This study demonstrates how multiple techniques can be combined to identify how plants cope with drought through different drought-tolerance strategies and the consequences of such changes on below-ground organic matter composition.
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