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Symbiotic dinitrogen fixation enhances soil phosphorus acquisition strategies in tropical forests

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Symbiotic dinitrogen (N_2) fixation – a process that allows some plants to overcome nitrogen (N) limitation by converting atmospheric N_2 into bioavailable forms – is an energetically expensive mutualism that requires carbon and phosphorus (P) from host plants to support their microbial symbionts. Ecological theory suggests that N_2 fixers – and N_2 fixation – should have a competitive advantage in low N-high P environments, but be outcompeted – or down-regulated – in high N-low P environments. Yet, N_2 fixers are relatively rare in N-poor temperate forests, but abundant and active in N-rich lowland tropical forests. Previous research addressing this paradigm hypothesized that N_2 fixers have the capacity to acquire more soil P than non-N_2 fixers because they can invest fixed N_2 in extracellular phosphatase enzymes, giving N_2 fixers a competitive advantage in acquiring this often-limiting nutrient. We tested this hypothesis, as well as the potential ability for N_2 fixers to host more arbuscular mycorrhizal (AM) fungi than non-N_2 fixers, by comparing enzyme activities and AM colonization between active N_2 fixers and non-N_2 fixers in two lowland rainforest sites that compose a soil P gradient in Costa Rica. At both lowland rainforest sites, phosphatase enzyme activity and AM colonization were significantly greater on the roots of N_2 fixers than non-N_2 fixers. Also, AM colonization was strongly and positively related to both N_2 fixation rates and nodule biomass, and the nature of the relationships was similar between both lowland rainforest sites. This indicates a potential link between the two mutualistic strategies of acquiring soil N and P, though the mechanism enabling N_2 fixers to host more AM fungi than non-N_2 fixers remains unclear. Overall, our results show a consistent set of N and P interactions across a range of plant species in two functional groups (i.e., N_2 fixers and non-N_2 fixers), and across a large gradient of soil total and extractable P that comprise the two lowland rainforest sites. Our results also suggest that the enhanced P acquisition strategies provide N_2 fixers with a competitive advantage in nutrient acquisition across a wide range of soil nutrient conditions found in the tropics, and perhaps contributing to their relatively high abundance in tropical forests.