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Multiple nutrients constrain fine root functioning in a lowland tropical rainforest in central Amazon

Laynara Figueiredo Lugli (1), Jessica Schmeisk Rosa (2), Renata Vilar Almeida (2), Kelly Andersen (1,3,4), Luiz E. O. C. Aragao (5), Rafael L. Assis (2), Jose L. Camargo (2), Amanda L. Cordeiro (2,6), Hellen F. V. Cunha (2), Raffaello Di Ponzio (2), Lucia Fuchslueger (7), Patrick Meir (8), Lina M. Mercado (1,9), Carlos A. Quesada (2), Karst J. Schaap (2), and Iain P. Hartley (1)

(1) University of Exeter, College of Life and Environmental Sciences, Geography, Exeter, United Kingdom (lf313@exeter.ac.uk), (2) National Institute for Amazonian Research, INPA, Manaus, Brazil, (3) School of Geosciences, University of Edinburgh, Edinburgh, UK, (4) Asian School of the Environment, Nanyang Technological University, Singapore, Malaysia, (5) National Institute for Space Research, Sao Jose dos Campos, Sao Paulo, Brazil;, (6) University of California, Los Angeles, Department of Geography, Los Angeles, USA, (7) University of Antwerp, Department of Biology, Plants and Ecosystems, Antwerp, Belgium, (8) Research School of Biology, Australian National University, Canberra, Australia, (9) Centre for Ecology and Hydrology, Wallingford, UK

The majority of forests across the Amazon basin grow in low fertility soils and plants might use a wide range of above and belowground mechanisms to overcome nutrient limitation. Phosphorus is hypothesised to be the main nutrient limiting tropical forest productivity, but more recent evidence suggests that multiple nutrients could regulate forest functioning. Belowground, root functional traits usually represent a balance between maximising the acquisition of limiting resources and minimising root tissue construction and maintenance. On low-fertility sites, plant economic theory predicts that if the supply of the limiting nutrient in soils is increased, plant investment in root biomass and nutrient uptake strategies should decrease. To test this, we investigated the response of fine root properties to the addition of nutrients in slow-growing primary rainforest established on low fertility soils in central Amazon. Using the ingrowth core method, we sampled young fine roots (<2 mm diameter) and measured root morphological traits (root diameter, specific root length, specific root area and root tissue density), root biomass production, root phosphatase enzyme activity and root mycorrhizal colonisation in 32 plots after seven months of phosphorus, nitrogen (N) and cations addition in a fully factorial design. We hypothesised that the addition of P would reduce root productivity, phosphatase activity and mycorrhizal colonisation, with root morphology shifting as a sign of alleviation of P limitation by increasing root diameter and tissue density and decreasing specific length and area. We also hypothesised that the addition of N and/or cations would exacerbate P limitation and therefore root productivity and phosphatase exudation would increase, with morphological traits changing towards finer and longer roots. Contrary to expectations, root productivity in the first seven months post-fertilisation was >50% higher in plots where cations were added, with no effects of P or N addition observed. The addition of cations and P increased root diameter, mainly for the 0-10 cm soil layer, with no significant effects on other root morphological traits. As predicted, root phosphatase activity strongly decreased with P addition, indicating alleviation of P limitation. Mycorrhizal colonisation, on the other hand, increased with P addition, suggesting a potential shift in P-uptake strategies, from mining (e.g. release of phosphatases) to foraging root traits (e.g. association with mycorrhizas). These results support the hypothesis that P limits some aspects of plant functioning in this central Amazon forest, but also suggest that cations could play an important role in controlling fine root production and the expression of root traits. Multiple nutrients may limit belowground processes in central Amazon forests and even slow-growing tropical rainforest can respond rapidly to changes in soil nutrient availability. These results therefore shed new light on the belowground mechanisms by which tropical forests thrive under low soil fertility, and contribute to the aim of better understanding Amazon forest functioning under current and future climate.