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The effects of elevated CO_2 and phosphorus limitation shaping fine root functioning in Central Amazon forests

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One of the most important questions that remain open in terrestrial ecology refers to how the Amazon rainforest, the largest tropical forest in the world, will respond to elevated atmospheric CO_2. Since a large part of the Amazon grows in soils with very low phosphorus (P) availability, understanding how potential nutrient limitation could impact forests in a changing world becomes crucial. There is strong evidence for a positive effect of elevated CO_2 on plant growth but sustaining such a response in the Amazon would require plants to increase their access to P, making it important to understand the effects of elevated CO_2 on root P-uptake strategies. To this end, we installed eight Open Top Chambers (OTC) in an understory forest in Central Amazon in Manaus, Brazil, being four control with ambient CO_2 (aCO_2) and four treatment with +200 ppm CO_2 (eCO_2). *Inga edulis,* a common N-fixing tree in the area, was chosen as study species. In each OTC, *I. edulis* was grown in six pots, three containing control soil from the study area and three containing control soil with 600 mg/kg of P added as triple super phosphate. After two years, plants were harvested and total soil respiration, total root dry mass, root nodulation, root morphological traits (mean diameter, specific root length – SRL, specific root area – SRA and root tissue density – RTD) and potential root phosphatase activity were measured. Total soil respiration was significantly higher in both treatments with eCO_2 when compared to treatments with aCO_2. Total dry root biomass followed a similar pattern, and root biomass in the eCO_2 and P+eCO_2 treatments were twice that of the other two aCO_2 treatments. Plants invested in more fine roots (< 1 mm diameter) than in coarse roots with eCO_2-only, whilst in P+eCO_2, both fine and coarse roots biomass increased. No nodules were detected in control plants, whilst almost 75% of plants growing in P+eCO_2 and 30% of plants growing in eCO_2-only and P-only displayed nodulation. Mean fine root diameter for plants growing in eCO_2-only was significantly higher than all other treatments, leading to a significant decrease in SRL and RTD, with no changes in SRA. In both treatments with eCO_2, fine root phosphatase activity (expressed per root dry mass and specific area) significantly decreased in comparison to aCO_2. However, when extrapolating root phosphatase activity for total fine root biomass, pot-level phosphatase exudation was twice as high in eCO_2 than in aCO_2 treatments. Our results clearly point to a shift in plant belowground strategies, suggesting an even stronger control of nutrient acquisition mechanisms by eCO_2 than P addition. With eCO_2, plants allocated much more biomass to fine roots and nodules, rather than increased phosphatase exudation per root-unit. Such trade-off suggests that in this scenario, plants might acquire P directly by exploring higher soil volumes, whilst allocating extra C to N-fixing bacteria. We demonstrate how eCO_2 and P availability can shape belowground plant traits pointing to important trade-offs that could determine ecosystem-scale changes in future climate scenarios.

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