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Initial responses of fine root dynamics of understory plants to elevated CO_2 in a Central Amazon rainforest

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In large parts of the Amazon rainforest low soil phosphorus availability may prevent the stimulation of forest growth in response to elevated atmospheric CO_2 (eCO_2). One strategy of plants could be to increase the relative allocation of the extra C belowground to their root systems to enhance nutrient acquisition and alleviate the potential phosphorus limitation, but little is known about the responses of tropical lowland forest species. We hypothesized that in tropical understory plants will trigger a first a fast upregulation of fine root phosphatase activities, followed by changes in fine root productivity and adaptions of morphological parameters, such as specific root length (SRL), specific root area (SRA) and root tissue density (RTD) to enhance phosphorus mobilization, increase its availability and exploit a larger soil and litter volume.

We tested our hypothesis in the first CO_2 enrichment experiment in Central Amazonia at a low soil phosphorus site, increasing CO_2 levels by 200 ppm relative to CO_2 ambient (aCO_2) concentrations using open top chambers (OTC) in the forest understory. We monitored potential root phosphatase activity, root productivity, and morphological traits in the soil with ingrowth cores (0-15 cm) and in the litter layer, as well as root biomass stocks in 0-5 and 5-10 cm of depth.

In contrast to our hypothesis, we observed a reduction in fine root productivity (<1mm diameter), from 0.038 ± 0.01 mg cm^2 day^{-1} under aCO_2 to 0.013 ± 0.004 mg cm^2 day^{-1} after 12 months of eCO_2. On the other hand, the fine root biomass stock (<2mm diameter) increased at 5-10 cm from 0.86 ± 0.18 at aCO_2 to 1.74 ± 0.65 mg^{-1} cm^2 with eCO_2, but there was no effect of eCO_2 on fine root biomass in the litter layer. However, roots growing in the litter layer significantly increased their SRL and showed a strong tendency of higher SRA in response to eCO_2 (SRL: 4.66 ± 1.08 and 9.58 ± 2.12 cm mg^{-1}; SRA: 0.63 ± 0.18 and 1.0 ± 0.25 cm^2 mg^{-1} with aCO_2 and eCO_2, respectively), but we

did not observe changes in root morphological parameters in the soil, only a tendency towards decreasing RTD. Moreover, we found a strong trend towards an increase in potential root phosphatase activity with eCO_2 in the litter by 20.0 % (aCO_2: 66.16 ± 10.4; eCO_2: 79.39 ± 20.8 nmol mg^{-1} dry root h^{-1}) and soil by 45.61% (aCO_2: 97.42 ± 30.76; eCO_2:141.86 ± 34.04 nmol mg^{-1} dry root h^{-1}).

Our initial results suggest that understory plants intensified the investment in fine root dynamics in litter layer as response to eCO_2 (e.g., increase in SRL and potential root phosphatase activity) Furthermore, with a potential increase in root phosphatases exudation (litter and soil) in the first year with eCO_2, our results reinforce the importance of this mechanism to mobilize inorganic P. Our results provide an initial understanding of nutrient mechanisms acquisition under eCO_2 in a tropical forest, which can be incorporated into ecosystem models to allow more reliable predictions of forest productivity under eCO_2.

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