Spatial variation of photosynthesis in tropical pristine forests: saplings vs. adults

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The role of phosphorus?

Understanding what determines the spatial variation of photosynthesis is crucial for modelling canopy photosynthesis. Within canopy variation is often explained by leaf stoichiometry. Trees optimise their nitrogen (N) allocation to maximise photosynthetic capacity under the different light conditions. The role of phosphorus (P) in this relationship is still unknown, but low P might influence how N is used (Reich et al. 2009).

Research aims

Determine the drivers of variation in leaf photosynthesis through (1) studying the vertical variation in photosynthesis, (2) the role of nutrients, and specifically P, on this variation and (3) how these patterns vary spatially.

Study site

The tropical forests of French Guiana are very poor in soil P availability. At our study site the soil Olsen P concentration ranges from 2.3 ppm in the bottomland to 1.5 ppm at the terra firme, whereas inorganic N ranges from 9.2 to 18.6 ppm.

The plots of this study are situated in Paracou, a forest site 100 km west of the capital Cayenne.

Methodology

We carried out 468 gas exchange measurements at different height levels in the canopy of 8 plots distributed over two topographic positions. We compared gas exchange of upper canopy, lower canopy, and saplings.

Focus is on 5 common families:

• Fabaceae (n = 110),
• Lecythidaceae (n = 69),
• Myristicaceae (n = 42),
• Annonaceae (n = 41),
• Chrysobalanaceae (n = 33).

Figure 1. Measuring photosynthesis with a Li-6400XT (left) in the canopy and (right) on saplings in the tropical forest of French Guiana.

Results

Vertical variation

The carboxylation rate, Vcmax, and the electron transport rate, Jmax, increase with increasing height level in the canopy. Leaf P explains this vertical variation in both Vcmax and Jmax – note the separation of upper canopy leaves for P and Vcmax or Jmax. We did not find differences in leaf N between upper and lower canopy for adult trees.

Co-limitation N and P?

Domingues et al. (2010) reported co-limitation of photosynthetic capacity by N and P in West African woodlands. When we apply this model to our data, the model generally overestimates values for Vcmax and Jmax. Is another factor co-limiting the photosynthetic capacity?

The role of phosphorus!

At our field site the vertical profile is determined more by P than by N. Since most vegetation models use N to model photosynthetic capacity, this information is crucial to improve these models. Spatial variation of photosynthetic capacity was not found. Both Vcmax and Jmax are not well explained by the co-limitation by N and P. In the near future we will study this in more detail.

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Further information

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