A05 - Trace gas fluxes, soil-N cycling, and nutrient leaching losses in Acrisol soils under rainforest transformation systems

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Background

Tropical soils are globally important sources/sinks of the climate-relevant trace gases: nitric oxide (NO), nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2). These trace gases all have in common that they are produced and consumed in soils through microbially-mediated processes, which strongly depend on soil chemical and physical characteristics. Transformations of rainforests in regions like Sumatra have profound effects on soil chemical, physical and biological characteristics which, in turn, strongly influence nutrient cycling and losses (i.e. trace gas fluxes and leaching).

Objectives

Assess the impacts of rainforest transformation to jungle rubber, rubber plantation, and oil palm plantation on:

1) soil-nitrogen (N) cycling rates
2) soil-atmosphere exchange of trace gases
3) nutrient leaching losses

Nutrient leaching losses

Methods

- Whole-year measurements of leaching losses (DOC, DON, NH_4^+, NO_3^-, K, Na, Ca, Mg, total Al, total Fe, total Mn, total S, total P, total Si, and Cl) at the 32 core sites, using suction cup lysimeters installed at 1.5-m depth. Drainage flux was calculated using a water model, parameterized with site conditions, and validated with field measurement.

Status: All soil water sampling and laboratory analysis for measuring nutrient concentration have been completed.

Results

- In oil palm plantations, large mineral N leaching losses (i.e. loam Acrisol soil) were due to N fertilization, and the largest base cation losses (i.e. both in loam and clay Acrisol soils) were attributable to liming **(Fig. 1)**.

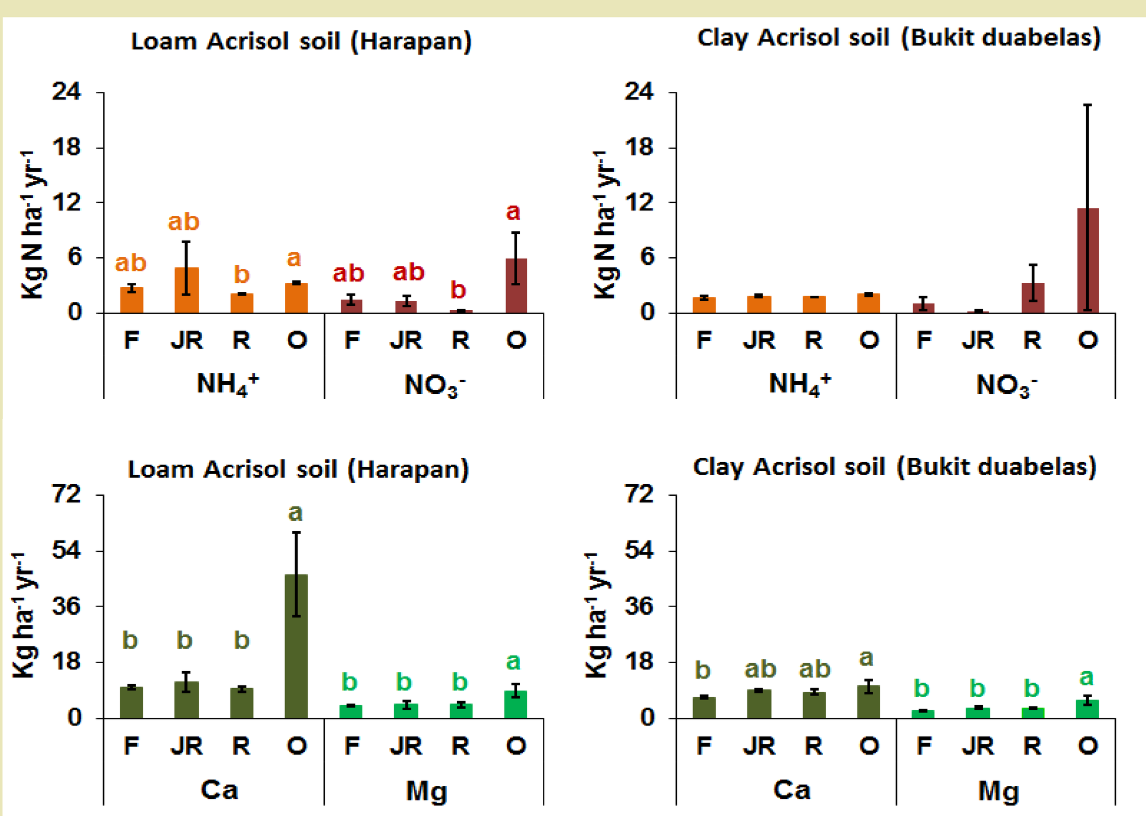

Fig.1. *Annual (± SE, n = 4 plots) nutrient leaching fluxes measured in 2013 at 1.5-m depth from different land uses in the loam Acrisol soil (Harapan) and clay Acrisol soil (Bukit duabelas), Jambi, Sumatra, Indonesia. Different lower case letters indicate significant differences among land uses for each landscape (Linear mixed effects models with Fisher's LSD test at P ≤ 0.05, except P ≤ 0.09 for Mg in the loam Acrisol soil). F = forest; JR = jungle rubber; R = rubber plantation; O = oil palm plantation*

Soil-N cycling

Methods

- Gross rates of microbially-mediated soil-N cycling at 32 core sites were measured using ^{15}N pool dilution techniques.

Results

- Soil N availability strongly hinged on microbial biomass, which in turn were correlated with soil fertility **(Fig. 2)**.
- Soil N availability was higher in the reference land uses (i.e. forest and jungle rubber), intermediate in fertilized oil palm and lowest in unfertilized rubber

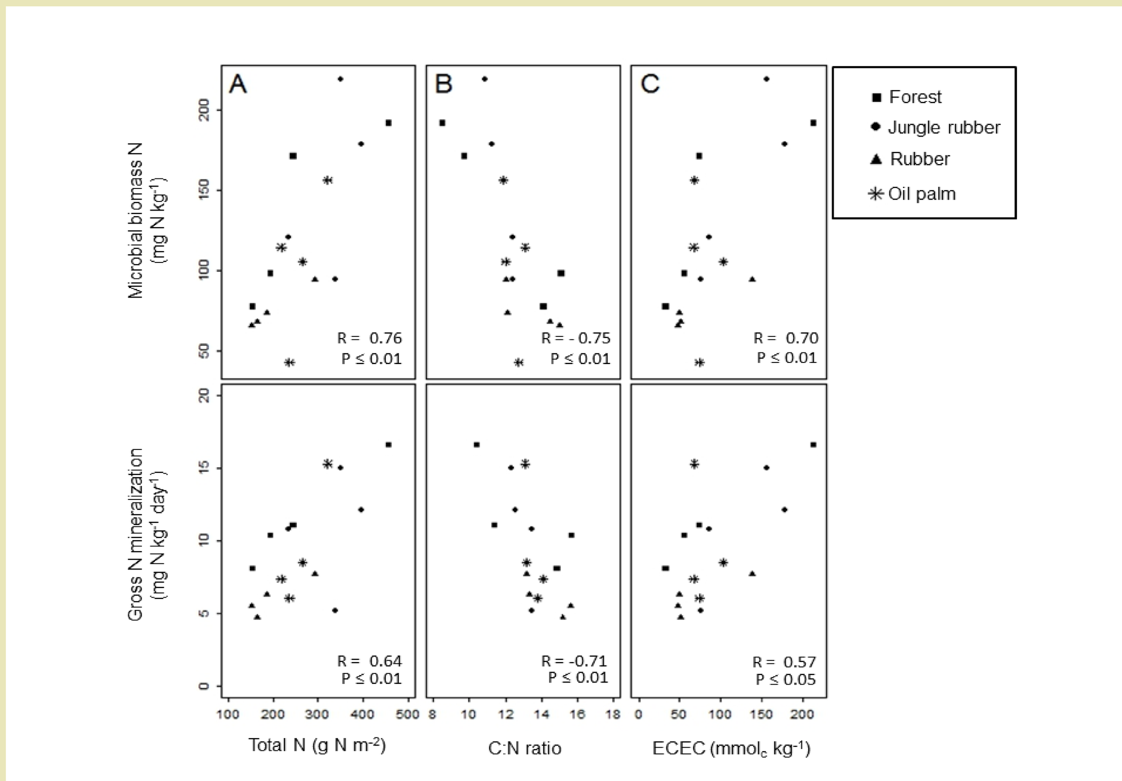

Fig. 2. *Spearman rank correlations of microbial biomass N (top panels) and gross N mineralization (lower panels) with soil (A) total N, (B) C:N ratio and (C) effective cation exchange capacity (ECEC) across land-use types within the clay Acrisol soil (n = 16) in Jambi, Sumatra, Indonesia.*

Soil-atmosphere exchange of trace gases

Methods

- Whole-year measurements of soil CO_2, CH_4 and N_2O fluxes, soil factors known to control soil-atmosphere trace gas exchange, and four-month measurements of NO fluxes at the 32 core sites. In oil palm plantations, we conducted in-situ incubations of organic debris gathered on leaf axils in order to detect aboveground sources of CH_4 and N_2O.

Status: All measurements have been completed and trace gas samples analyzed.

Results

- Soil CO_2 fluxes from oil palm plantations were lower compared to the other land uses in both landscapes, and soil CH_4 uptake rates in the plantations were lower compared to jungle rubber in both landscapes **(Fig. 3)**. Soil N_2O fluxes did not differ among land uses.

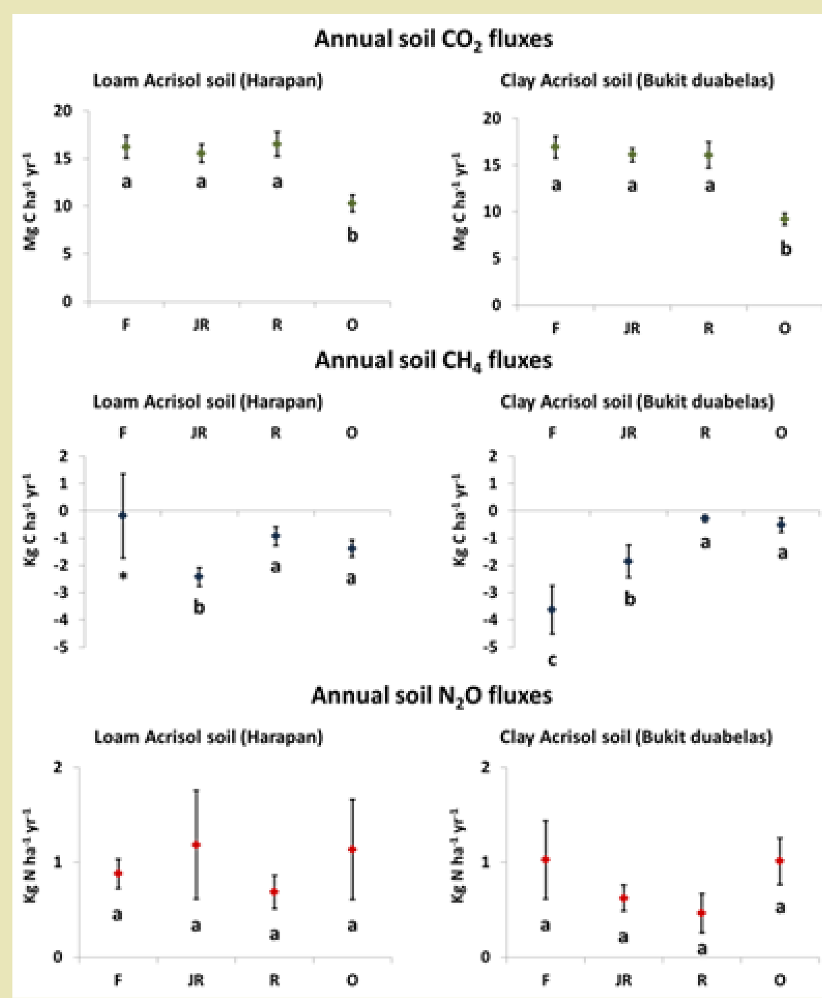

Fig. 3. *Annual (± SE, n = 4 plots) soil CO_2, CH_4 and N_2O fluxes from different land uses in loam Acrisol soil (Harapan) and clay Acrisol soil (Bukit duabelas), measured monthly from December 2012 to December 2013. Different letters indicate significant differences among land uses for each soil landscape (Linear mixed effects models with Fisher's LSD test at P ≤ 0.05). * Comparison excludes forest where two sites had dominantly net CH_4 emissions. F = forest; JR = jungle rubber; R = rubber plantation; O = oil palm plantation*