Ecosystem-based greenhouse budgets in oil palm plantations differ with plantation age

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1. Introduction

Global increase in demand of palm oil is leading to the expansion of oil palm plantations, particularly in SE Asia. Oil palm plantations in Sumatra and Kalimantan, Indonesia, are responsible for half of the world's palm oil production. Available studies point to plantations being large carbon dioxide (CO_2) sinks due to the high photosynthetic rates of oil palm as a result of high fertilizer inputs, especially in large-scale plantations. However, methane (CH_4) uptake in the soil of oil palm plantations is reduced and soil nitrous oxide (N_2O) emissions increased after nitrogen (N) fertilization. Greenhouse gas (GHG) budgets at the ecosystem level are still missing, and there is a lack of knowledge on the changes of these GHG budgets with plantation age.

2. Objective

To quantify CO_2, CH_4 and N_2O fluxes during the nonproductive (young, 2 yr-old) and productive (mature, 12 yr-old) phases of oil palm cultivation, using eddy covariance and chamber based measurements.

3. Methods

Two study sites:

2-yr old (nonproductive) oil palm plantation

12-yr old (productive) oil palm plantation

Both sites were on Acrisol soils and were located in Jambi province, Sumatra (Fig. 1)

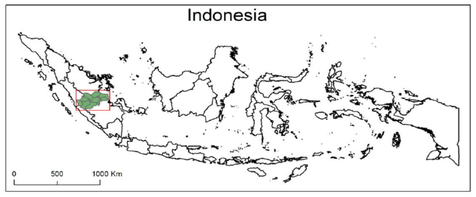


Fig. 1: Study area - Jambi province, Sumatra

3.1. Eddy covariance measurements

2-yr old: 7 m tower
CO_2 and H_2O
(Licor 7500A)

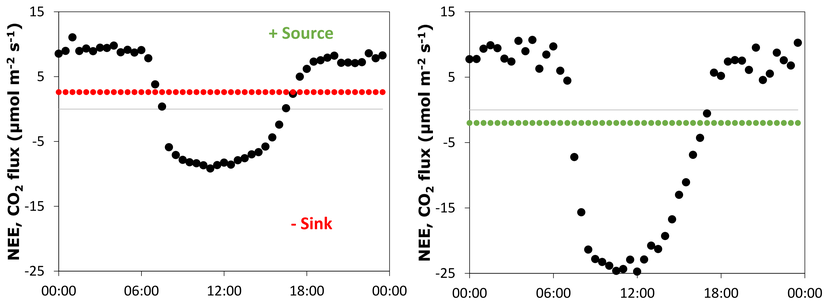
12-yr old: 22 m tower
CO_2, H_2O and CH_4
(Licor 7500A and FGGA, Los Gatos)

3.2. Chamber measurements

Static vented chambers along the tower footprint:
- soil CO_2, CH_4 and N_2O emissions
- analysis by gas chromatography

4. Results and discussion

2 yr-old plantation was a CO_2 source while 12-yr old one was a CO_2 sink (Fig. 2).



2-year old → daily: 2.6 g C m^{-2} d^{-1}
→ yearly: 990 g C m^{-2} yr^{-1}

12-year old → daily: -2 g C m^{-2} d^{-1}
→ yearly: -790 g C m^{-2} yr^{-1}

Fig. 2: Diurnal cycles of net ecosystem exchange (NEE) of CO_2 in 2-yr old (left) and 12-yr old (right) plantations. In the bottom of the figures are daily and yearly sums. Colored horizontal lines represent diurnal sums.

Similar soil CH_4 uptake was observed in both plantations, resulting in a small C sink. N_2O fluxes were high in the 12-yr old plantation (Fig. 3) due to high N fertilization rates (up to 196 kg N ha^{-1}), and lower in 2-yr old plantation.

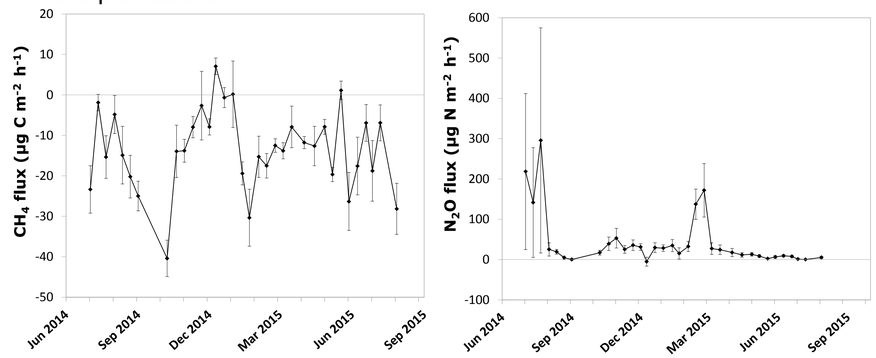


Fig. 3: One year of CH_4 (left) and N_2O (right) fluxes in the 12-yr old plantation.

2-yr old plantation was a GHG source while 12-yr old was a sink. When harvest is considered, both plantations were strong sources of CO_2-eq.

	CO_2	CH_4	N_2O	GWP	Yield	GWP with yield
	g CO_2-eq m^{-2} yr^{-1}				g C m^{-2} yr^{-1}	g CO_2-eq m^{-2} yr^{-1}
2-yr old	990	~-36	---	954	---	954
12-yr old	-2903	-36	153	-2786	1104	1262

Table 1: Annual GHG emissions and global warming potential (GWP) in 2 and 12-yr old plantations.

5. Conclusions

- GWP of a nonproductive oil palm plantation was dominated by CO_2 fluxes.
- In the productive plantation, the contribution of N_2O to the GWP was significant due to high N fertilizer input.
- Our results highlight the need of evaluating various stages of development of oil palm cultivation when assessing their GHG budgets at a regional scale in order to support quantitative-based mitigation strategies.

Acknowledgements

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