N_2O emissions from oil palm on mineral soils: measurements and modelling challenges

Pardon L.[1], Bessou C.[1], Saint-Geours N.[2], Gabrielle B.[3], Marichal R.[1,4], Testiati E.[4], Caliman J.-P.[1,4], Nelson P.N.[5]

[1]CIRAD, UPR Systèmes de pérennes, F-34398 Montpellier, France
[2]ITK, CEEI CAP ALPHA Avenue de l'Europe, 34830 Clapiers, France
[3]AgroParisTech, INRA, UMR EcoSys, 78850 Thiverval-Grignon, France
[4]SMART Research Institute, Jl. Tengku Umar 19, Pekanbaru, 28112, Indonesia
[5]College of Science, Technology and Engineering, James Cook University, Cairns, Australia

Contact: lenaic.pardon@cirad.fr

N_2O emissions from agriculture greatly contribute to climate change. In palm plantations on mineral soils, these emissions are mostly due to fertiliser inputs. This raises environmental concerns as oil palm is the most rapidly expanding tropical perennial crop. There is hence a critical need to quantify and model N_2O emissions in order to explore suitable practices to reduce these emissions.

Material & Method

- Review of available measurements for N_2O and other nitrogen losses in oil palm plantations on mineral soils. NH_3, NO_x and NO_3 losses may lead to further indirect emissions of N_2O [1].
- Comparison of 25 sub-models to simulate N losses, among which:
  - 8 were specific to leaching and runoff (NO_3 losses)
  - 9 were specific to NH_3 volatilisation
  - 8 were specific to N_2O emissions

Soil flux measurements.

Application of palm organic residues.

Decomposing felled palm trees.

Tower for flux measurement.

Application of palm organic residues.

Results

Sources and amounts of N_2O

- Direct N_2O emissions were the most uncertain N flux varying between 0.01-7.3 kg $N.ha^{-1}.yr^{-1}$, with a tendency to be higher during the immature phase, to decrease with the age of palms and to be higher in poorly drained soils [2-3]. However, only few measurements were available.
- Indirect N_2O emissions were related to emissions of NH_3 and NO_3^- which were particularly high during the immature phase when the N inputs are high while the palms are still young.

Modelling of N_2O emissions

- Direct N_2O emissions estimates were some of the most variable across models between 0.3-7 kg $N.ha^{-1}.yr^{-1}$, albeit close to field measurements. Mineral fertilisers were identified as the main contributor to the emissions, but plant residues and soil N mineralisation were also important.
- The models accounting for felled palms decomposition, empty fruit bunches applications, and biological N fixation also estimated a peak in N_2O emissions during the immature phase. The main influential factors on N_2O emissions were the rate of mineral fertiliser applied and the emission factors of the models.

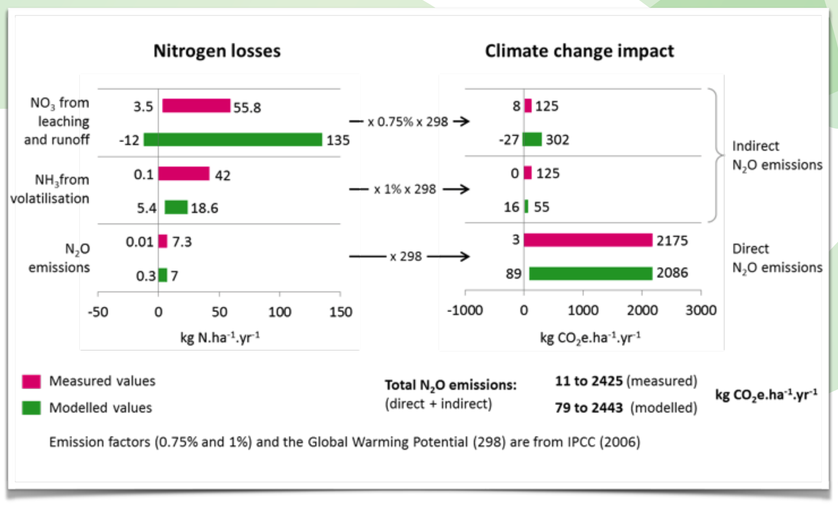

Figure 1. Comparison of measured and modelled values for nitrogen losses and climate change impact in oil palm plantations.

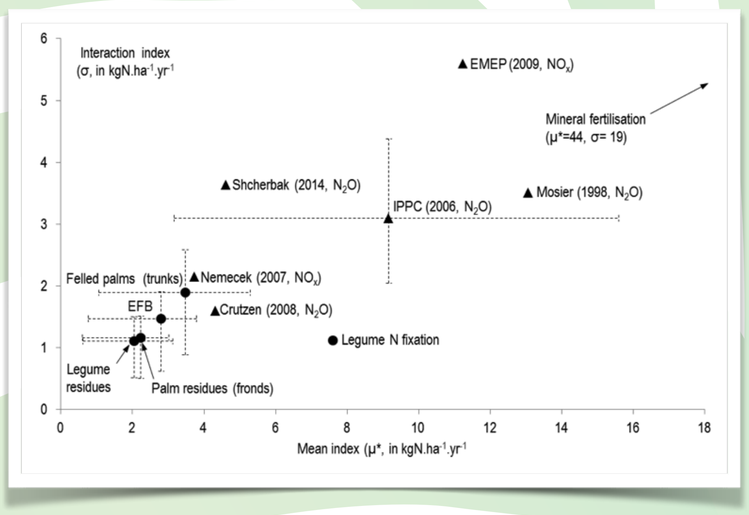

Figure 2. Morris's sensitivity indices for sub-models calculating N_2O, NO_x, and N_2 emissions.

Conclusion

Data is still lacking to better understand the potential effects of spatial heterogeneity in plantations and management practices on direct and indirect N_2O emissions. More field measurements are needed. They will allow for improving current models, e.g. IPCC, and for improving practices towards reducing N losses and related economic and environmental losses.

References

[1] **Pardon L., Bessou C., Nelson P. N., Dubos B., Ollivier J., Marichal R., Caliman J-P, Gabrielle B. (2016)** Key unknowns in nitrogen budget for oil palm plantations. A review. Agronomy for Sustainable Development.

[2] **Ishizuka S., Iswandi A., Nakajima Y., Yonemura S., Sudo S., Tsuruta H., Murdiyarso D. (2005)** The variation of greenhouse gas emissions from soils of various land-use/cover types in Jambi province, Indonesia. Nutr. Cycl. Agroecosystems 71, 17–32.

[3] Banabas M. (2007) Study of nitrogen loss pathways in oil palm (*Elaeis guineensis* Jacq.) growing agro-ecosystems on volcanic ash soils in Papua New Guinea. Ph.D. Thesis in Soil Science at Massey University, Palmerston North, New Zealand.

5th International Conference on Oil Palm & Environment
ICOPE 2016
16th - 18th March 2016
The Westin Resort Nusa Dua-Bali, Indonesia

smart agribusiness and food
JAMES COOK UNIVERSITY AUSTRALIA
INRA SCIENCE & IMPACT
AgroParisTech
cirad
www.cirad.fr