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.[1,5], Testiati E.[5], Caliman J.P.[1,5], Nelson P.N.[6]

[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]World Agroforestry Centre (ICRAF), Southeast Asia Regional Programme, Bogor, Indonesia
[5]SMART Research Institute, Jl. Tengku Umar 19, Pekanbaru, 28112, Indonesia
[6]College of Science, Technology and Engineering, James Cook University, Cairns, Australia
Contact: lenaic.pardon@cirad.fr

ABSTRACT

In oil palm plantations, addition of nitrogen (N) via legume cover crops and fertilisers is a common practice to achieve the yield potential of the crop. It is associated with effects on climate change through emissions of N_2O (Choo et al., 2011). As oil palm is the most rapidly expanding tropical perennial crop, and is expected to keep expanding in the next decades (Corley, 2009), this raises environmental concerns.

We reviewed the available measurements for N_2O and other N fluxes in oil palm plantations on mineral soils (Pardon et al., 2016). We saw that direct N_2O emissions were the most uncertain N flux, ranging from 0.01 to 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 (Ishizuka et al., 2005; Banabas, 2007). However, only very few measurements were available on mineral soils, and data is still lacking to better understand the potential effects of spatial heterogeneity in plantations (soil properties, soil cover) and management practices (e.g. fertiliser application timing, splitting, placement). 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.

We compared 11 existing models and 25 sub-models to simulate oil palm N budget and losses, among which 8, 9 and 8 sub-models were specific to N_2O emissions, NH_3 volatilisation, and NO_3^- losses through leaching and runoff; respectively (Pardon et al., under review). We saw that direct N_2O emissions estimates were some of the most variable across models, ranging from 0.3 to 7 kg N ha^{-1} yr^{-1} (Mosier et al., 1998; Bouwman et al., 2002b; IPCC 2006, from Eggleston et al., 2006; Crutzen et al., 2008; Meier et al., 2012; APSIM from Huth et al., 2014 ; Shcherbak et al., 2014). The main influential factors on direct N_2O emissions were the rate of mineral fertiliser applied and the emission factors of the models. The models accounting for felled palms decomposition, empty fruit bunches applications, and biological N fixation also estimated a peak of N_2O emissions during the immature phase.

Therefore direct and indirect emissions of N_2O in oil palm plantations seemed not to be negligible in terms of environmental effect, with ranges of 11 to 2,425 and 79 to 2,443 kg CO_2e ha^{-1} yr^{-1} for measured and modelled values; respectively (assuming a global warming potential of 298 for N_2O). However, in order to be able to adapt management practices to mitigate these emissions, knowledge is still lacking to better understand the potential effects of spatial heterogeneity and management practices on direct and indirect N_2O emissions.

The main modelling challenges are to model the impact of management practices, taking into account the soil N dynamics and residues decomposition, and this over the whole cycle.

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