Geophysical Research Abstracts
Vol. 19, EGU2017-5177-1, 2017
EGU General Assembly 2017

Ground and canopy soil N2O fluxes from smallholder oil palm plantations following deforestation in Sumatra, Indonesia

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Due to an increasing global demand in cheap oils and biofuels, forest conversion to oil palm plantations is rapidly increasing in Indonesia. Although forest conversion is known to influence soil N2O fluxes, measurements from oil palm are scarce. Our study aimed to (1) quantify changes in soil N2O fluxes with forest conversion to oil palm plantations, (2) quantify the contribution of oil-palm canopy soil (lodged between the stems and leaf axils) to N2O fluxes, and (3) determine their controlling factors. In Jambi, Sumatra, we selected two landscapes that mainly differed in soil texture but both on heavily weathered soils: loam and clay Acrisol soils. Within each landscape, we investigated lowland forest, jungle rubber (rubber trees interspersed in secondary forest), both as the reference (previous) land uses, and the converted oil palm plantations by smallholders. Each land use had four replicate plots within each landscape. Each replicate plot had four permanently placed chambers, and soil N2O fluxes were measured monthly from December 2012 to December 2013 by placing vented static covers on chamber bases for 30 minutes for gas flux measurement. For oil-palm canopy soil, each replicate plot was represented by five oil palms, and each oil palm stem was delineated into three 1-m sections (low, middle, and top) in order to represent possible gradients of canopy soil conditions that influence N2O fluxes. Measurements were conducted from February 2013 to May 2014 by collecting canopy soil from each stem section and incubating it in-situ in an air-tight glass jar. Land-use conversion to smallholder plantations had no effect on soil N-oxide fluxes ($P = 0.58$ to 0.76) due to the inherently low soil N availability and the low N fertilization rates (commonly 48 to 88 kg N ha-1 yr-1) of smallholder oil palm plantations. Soil N2O fluxes (kg N ha-1 yr-1) were: 0.6 ± 0.1 to 1.2 ± 0.6 from the reference land uses and 1.0 ± 0.2 to 1.1 ± 0.5 from the smallholder oil palm plantations. N fertilizer-induced N2O emissions were 0.2 – 0.7 % of the applied N. Oil-palm canopy soil N2O emissions per soil mass were large, but on a hectare basis these emissions were small due to the low amount of canopy soil per hectare (170 kg ha-1). Canopy soil N2O emission was 10.7 ± 3.3 g N2O-N ha-1 yr-1, which contributed only 1% of the total soil (canopy soil + ground soil) N2O fluxes. Over one-year measurements, the temporal patterns of ground and canopy soil N2O fluxes were controlled by soil mineral N and water contents. To improve estimate of soil N-oxide fluxes from oil palm plantations in this region, studies should focus on large-scale plantations (which usually have two to four times higher N fertilization rates than smallholders) with frequent measurements following fertilizer application.