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Impact of savanna conversion to oil palm plantations on C stocks dynamics and soil fertility

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Large-scale expansion of oil palm cultivation on forested land in South-East Asia during the last decades lead to high negative environmental impacts. Because rainforests store high amount of C, their conversion to oil palm plantations results in large net CO_2 emissions. Oil palm cultivation in tropical ecosystems such as savanna that store less C than forests is seen as an alternative to reduce greenhouse gas emissions of future oil palm development. While this option is more and more frequently mentioned, few data are available on the effective gain in C storage. Furthermore negative impact on soil organic carbon and soil fertility could offset gains of C storage in oil palm biomass. Here, we present results on aboveground and belowground C stocks and soil nutrient dynamics over a full rotation cycle of oil palm plantations established on tropical savanna grasslands. Three natural savanna grasslands as reference sites and 9 oil palm plantations ranging from two to twenty-seven years old were selected in the Llanos in Colombia. Oxisols were sampled down to 70 cm in each management zones of oil palm plantations (weeded circle, interrow, frond piles and harvesting path). Taking advantages of a shift from C4 to C3 vegetation, we quantified savanna-derived soil organic carbon (SOC) decomposition and oil palm-derived SOC stabilization rates and how they were affected by management practices (mineral fertilization, organic amendments, etc.). Results show that, in opposite to forest conversion, C storage increases when savannas are converted to oil palm plantations. Because soil C storage was very low in natural conditions, SOC changes had little effects on overall C storage. Substitution of savanna-derived SOC by oil palm-derived SOC was very fast in the topsoil and highest under frond pile and weeded circle where C and nutrients inputs are highest. However, stabilization of oil palm-derived SOC compensated loss of savanna-derived SOC rather than increased SOC stocks, indicating high SOC turnover. High turnover are explained by high nutrients inputs and little capacity of Oxisols to physically protect SOC. In conclusion, conversion of savanna to oil palm plantations results in a gain in ecosystem C storage as long as the cultivation lasts. Negative impacts on soil fertility are limited because savanna soils have low initial soil fertility. With more than 7 million ha of well-drained natural savanna grasslands, the Llanos could play a significant role in oil palm development. Nonetheless, a complete assessment of environmental impacts including biodiversity or water consumption is still necessary for the assessment on sustainability of the conversion of savanna to oil palm plantations.