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Effects of agricultural intensification in the tropics on soil carbon losses and soil fertility

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Tropical forest conversion to agricultural land leads to strong decrease of soil organic carbon (SOC). Nonetheless, the impacts of SOC losses on soil fertility remain unclear. We quantified SOC losses in forest, oil palm plantations, extensive rubber plantations and rubber monocultures on Sumatra Island (Indonesia). Furthermore, we assessed the response of biological (basal respiration, microbial biomass, acid phosphatase) and chemical fertility indicators (light fraction of OM, DOC, total N, available P) to SOC losses. We used a new approach based on (non-)linear regressions between SOC losses and the indicators, normalized to natural ecosystem values, to assess the sensitivity or resistance of fertility indicators to SOC losses. Carbon contents in the Ah horizon under oil palm and intensive rubber plantations were strongly reduced: up to 70% and 62%, respectively. The decrease was lower under extensive rubber (41%). The negative impact of land-use changes on all measured indicators increased in the following sequence: extensive rubber < rubber < oil palm. Basal respiration, microbial biomass and nutrients were comparatively resistant to SOC losses, whereas the light fraction of OM was lost faster than the SOC. The resistance of the microbial activity to SOC losses is an indication that microbial-mediated soil functions sustain SOC losses. However, responses of basal respiration and microbial biomass to SOC losses were non-linear. Below 2.7% C content, the relationship was reversed. The basal respiration decreased faster than the SOC, resulting in a stronger drop of microbial activity under oil palm compared to rubber, despite small difference in C content. We conclude that the new approach allows a quantitative assessment of the sensitivity and threshold of various soil functions to land-use changes and consequently, can be used to assess their resistance to agricultural intensification. Therefore, this method is appropriate to evaluate the environmental impacts associated with various scenarios of agricultural intensification in tropical regions, but needs also to be tested in different tropical climate and soil (mineral vs organic) conditions.