Impacts of afforestation and silviculture on the soil C balance of tropical tree plantations: belowground C allocation, soil CO2 efflux and C accretion *(Invited)*

Details

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Abstract

Tropical forest plantations will provide a large part of the global wood supply which is anticipated to increase sharply in the next decades, becoming a valuable source of income in many countries, where they also contribute to land use changes that impact the global carbon (C) cycle. Tropical forest plantations established on previous grasslands are potential C sinks offsetting anthropogenic CO2 emissions. When they are managed on short rotations, the aboveground biomass is frequently removed and transformed into wood products with short lifetimes. The soil is thus the only compartment for durable C sequestration. The soil C budget results from the inputs of C from litterfall, root turnover and residues left at logging stage, balanced by C losses through heterotrophic respiration and leaching of organic C with water flow. Intensive researches have been conducted these last ten years in eucalypt plantations in the Congo on the effects of management options on soil fertility improvement and C sequestration. Our aim is to review important results regarding belowground C allocation, soil CO2 efflux and C accretion in relation to management options. We will specifically address (i) the soil C dynamics after afforestation of a tropical savannah, (ii) the impact of post-harvest residue management, and (iii) the beneficial effect of introducing nitrogen fixing species for C sequestration. Our results on afforestation of previous savannah showed that mechanical soil disturbance for site preparation had no effect on soil CO2 efflux and soil C balance. Soil C increased after afforestation despite a rapid disappearance of the labile savannah-derived C because a large fraction of savannah-derived C is stable and the aboveground litter layer is as the major source of CO2 contributing to soil CO2 efflux. We further demonstrated that the C stock in and on the soil slightly increased after each rotation when large amounts of residues are left at logging stage and that most of eucalypt-derived C is recovered in the fine particulate organic matter fraction (0.25-0.05 mm) and the organo-mineral fraction (< 0.05 mm). While the early tree growth is related to the heterotrophic component of soil CO2 efflux, thus largely dependent on the nutrients released by the decomposition of organic residues left at harvest, the stabilization of the old soil organic C derived from the savannah may depends on the amount of organic residues left at harvest. A greater C accumulation was observed in the soil when eucalypts were grown in mixture with a nitrogen fixing tree despite similar aboveground litter fall and lower fine root biomass. A slowdown of C turnover related to N enrichment might thus be postulated in nitrogen-poor tropical soils, and mixed-species plantation with nitrogen fixing trees might be an important strategy of reforestation or afforestation to offset C emissions.

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