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Soil carbon storage and wabter consumption following afforestation of a tropical savannah with Eucalypts

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The increasing demand for wood products and for substitution of fossil energy by wood biomass is not satisfied by the exploitation of natural forests. Forest plantations are expected to provide a larger part of the global wood supply in the future and the extension of afforested area will mainly concern marginal areas. In the past 25 years, 430 km2 of clonal Eucalypt plantations have been established in the littoral savannah of Congo. Soil organic carbon is a key factor in the global carbon cycle, but the magnitude and the direction of its change after afforestation is still a matter of controversy and little is know about the water cost of carbon sequestration and wood production in these systems.

The objectives of this study were (i) to understand the dynamic of soil carbon in intensively managed Eucalypt plantations after the afforestation of a native savannah, (ii) to compare the water-use between native savannah and Eucalypt plantations to estimate the water cost of biomass production between clones differing in productivity and (iii) to relate the difference in water use efficiency to ecophysiological leaf traits of the two clones.

We partitioned soil carbon into savannah-derived and Eucalypt-derived organic matter by measuring the isotopic composition of soil carbon and soil CO2 efflux taking advantage of the fact that the C4-type organic matter of savannah grass is less depleted in 13C than the C3-type organic matter of Eucalypt. We quantified water-use by native savannah vegetation and two eucalypt plantations by measuring evapotranspiration by eddy-covariance ("flux tower") and we partitioned rainfall between green and blue water. We computed water-use efficiency of the two eucalypt clones from evapotranspiration and wood production and we measured leaf gas exchanges of the two clones.

The labile pool of savannah-derived soil carbon had a mean residence time of 4.6 y and it accounted for 30% of soil carbon in the top soil of the savannah (0-5 cm), and only 12% when the entire 0-45 cm soil layer was considered. The rapid decrease in labile savannah-derived soil carbon with time after plantation was more than compensated by an increase in Eucalyptus-derived carbon. Annual evapotranspiration of the two eucalypt stands consumed 55 to 65% of annual precipitation depending on years and clones, compared to 40% for the native savannah but remained below the annual precipitation (1200 mm on average). There is a marked difference in water use efficiency between savannah grass and Eucalypts The difference in stem wood production between clones (+35%) with a marginal increase in evapotranspiration (15%) opens perspectives for a sustainable increase in production that will not compromise the blue water / green water partitioning in this specific edapho-climatic context. However, not only water consumption but also the maintenance of long-term fertility of soils should be considered.