Climate Change and Sustainability of Eucalyptus Plantations in the Kouilou Basin (Congo-Brazzaville)

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Abstract

Since 1950 approximately, the savannah of the Congolese littoral has gradually been planted with Eucalyptus in dense populations exploited on rotations of seven years. To appreciate the sustainability of these plantations of Eucalyptus in the climate change context (the rainfall reduction), it is necessary to make a comparative study of energy, carbon, mineral and water balances of two ecosystems, i.e. the original savannah ecosystem, and the man-made ecosystem the Eucalyptus plantations that have succeeded it. The aim of this work is to study the water balance of the two ecosystems and more particularly their actual evapotranspiration (transpiration and evaporation).

In a six years-old Eucalyptus plantation (Eucalyptus PF1 and Eucalyptus 12ABL*saligna), mean height is 24.2 m, mean stem diameter at soil level is 0.17 m, stand density is 502 trees ha^{-1}, total basal area is 11.0 m^2 ha^{-1}, leaf area index is 3.2, total wood production is 118.5 m^3 ha^{-1}). In a savannah with Loudetia arundinacea, gross precipitations (Pi), throughfall (rain gauges) and soil water content (neutron probe) were measured weekly during the rainy season from November 1996 to April 1997, from November 1997 to April 1998, from November 1998 to April 1999 and during the dry season, from June to September 1997 and from June to September 1998. Actual evapotranspiration (E_a), net interception and transpiration were derived by the water balance equation method.

Moreover, transpiration was measured using the radial flow meter. The soil water profiles (soil water content and potential plotted to soil depth) were established, indicating of preferential water uptake zones and rooting depths of Eucalyptus plantation (5 m depth) and savannah species (3 m depth).

Throughfall, net interception during the rainy seasons (1996–97, 1997–98 and 1998–99) were 867 mm and 112 mm (89 and 11% of Pi) for the Eucalyptus plantation and 878 mm and 101 mm (90% and 10% of Pi) for the savannah, respectively. The mean seasonal daily actual transpiration of the plantation and savannah was 3.6 and 2.6 mm day^{-1} during the rainy season (November to April) and 1.4 and 0.9 mm day^{-1} during the dry season (June to September); the mean seasonal daily actual evapotranspiration of the plantation and the savannah was 4.2 and 3.2 mm day^{-1} (rainy season) and 1.4 and 0.9 mm day^{-1} (dry season); the total seasonal actual evapotranspiration was 767 mm and 579 mm (rainy season) and 183 mm and 121 mm (dry season), with total annual respectively 1127 mm for a plantation (95% of Pi) and 821 mm for a savannah (69% of % of Pi). During the year transpiration/potential evapotranspiration ratio (T/E_p) is related to the soil-water depletion: The T/E_p ratio of 0.79 was not reduced from field capacity (R_{FC} = 618 mm) until 65% of R_{FC} (402 mm), and then it decreased quickly to near zero (0–0.2) at wilting point or 53% of R_{FC} (R_{FC} = 309 mm). The drainage out of rooting depths of savannah during the rainy season of 1997–1998 and 1998–99, was of 827 mm, a total over 3 years (0, 390 and 438 mm); while the drainage out of rooting depths of Eucalyptus plantation was of 470 mm (0, 207 and 263 mm), a difference in drainage between two ecosystems of 357 mm a total over these three years (0, 183 and 174 mm).

The Eucalyptus plantation is man-made ecosystem which takes up and transpires every day throughout the year and uses all available water. The succession of several rain-deficient years will reduce the wood production of the plantation but, knowing that between 1949 and 1998 four successive rain-deficient years have only occurred once while the length of rotation is seven years; this dry episode does not compromise the survival of the plantation, although it reduces its wood production. The savannah has a cycle of vegetation such that at the end of the dry season (September) the water remaining in the rooting depths of savannah (15% of R_{AW}) (R_{AW} = 181 mm), is sufficient for three successive rain-deficient years to have no impact on its production.

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