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Environmental control of CO_2 assimilation rate and leaf conductance in two species of the tropical rain forest of French Guiana (*Jacaranda copaia* D. Don and *Eperua falcata* Aubl.)

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Introduction

The potential environmental limitations to forest tree production under subequatorial climatic conditions are not well understood. Despite important annual precipitation, drought in the atmosphere and in the soil is likely to play a limiting role, because: 1) significant climatic water deficits occur during the dry seasons; and 2) the rain forest species do not seem to have evolved efficient adaptative features against drought (Doley *et al.*, 1987). The present study was aimed at comparing the CO_2 assimilation and stomatal conductance behavior under natural conditions during the dry season in artifical 3 yr old stands of *J. copaia*, a long living pioneer species occurring in open sites, and of *E. falcata*, a common species of the mature forest canopy.

Materials and Methods

The study was performed at an experimental site of the Centre Technique Forestier Tropical in French Guiana (53° W, 5.2° N) with 2200 mm average annual rainfall. Total rainfall over the experimental period (1 September–15 October 1987) amounted to 67.8 mm, extreme air temperatures were 20 (night) and 34°C (day) and average potential evapotranspiration was 4.0 $mm \cdot d^{-1}$. The mean height of the studied trees was 3.6 m (*J. copaia*) and 2.4 m (*E. falcata*). *In situ* CO_2 assimilation rate (A) and leaf conductance (g) were determined by means of a portable gas-exchange measurement system (Li-Cor 6200; Li-COR, Lincoln, NE, U.S.A.). Prior to the measurements reported here, the within-tree variability of gas exchange was assessed and was shown to be related to the position of the whorls on the main orthotropic stem in *J. copaia* and to the position of the leaves on the plagiotropic branches in *E. falcata.* The data hereafter refer to the zone of maximum A and g. Leaf water potential values were determined with a Scholander pressure bomb.

Results and Discussion

The 2 species exhibited fundamentally different patterns of daily courses of A *vs* photosynthetic photon flux density (I_p) as is shown for a typical cloudless day in the beginning of the dry season in Fig. 1. With the exception of leaflet 12, *E. falcata* was characterized by daily changes in *A* being in close relationship with those in I_p, while *J. copaia* exhibited a diurnal pattern with a clear depression of *A* during the afternoon. Midday depression cannot entirely be taken into account by the concurrent stomatal closure, since in the *J. copaia* leaflets, *A* decreased at constant, or even slightly increasing, calculated intercellular CO_2 concentrations (Fig. 2), thus indicating that the changes in *A* are primarily due to alterations of mesophyll photosynthesis (Jones, 1985).

The midday depression of *A* in *J. copaia* was not related to the diurnal changes of leaf water potential (data not reported here). This is in good agreement with the findings of Küppers *et al.* (1986) which showed the absence of any role of leaf water status in explaining the afternoon depression of *A* in a range of species of the temperate zone. In fact, the diurnal changes in *A* in the *J. copaia* leaflets were clearly related to the changes of leaf-to-air water vapor pressure difference *(Δw)*, these latter being closely associated with the variations of leaf temperature (Fig. 3). It is not possible here to disentangle the possibly colimiting effects of *Δw* and high temperatures on *A*. But it is worth noting that, in a similar situation, Schulze *et al.* (1974) provided evidence for *Δw* being the factor responsible for decreasing *A* in *Prunus armeniaca*, a species growing in the Negev desert. Effects of *Δw* on mesophyll photosynthesis independent of leaf water status alterations were also observed by Tenhunen *et al.* (1987) and by Grieu *et al.* (1988).

The two species also responded differently to the soil water depletion cycle occurring during the dry season, with the gas exchange of *E. falcata* remaining unaffected (Fig. 4), whereas both *A* and *g* were markedly reduced in *J. copaia*.

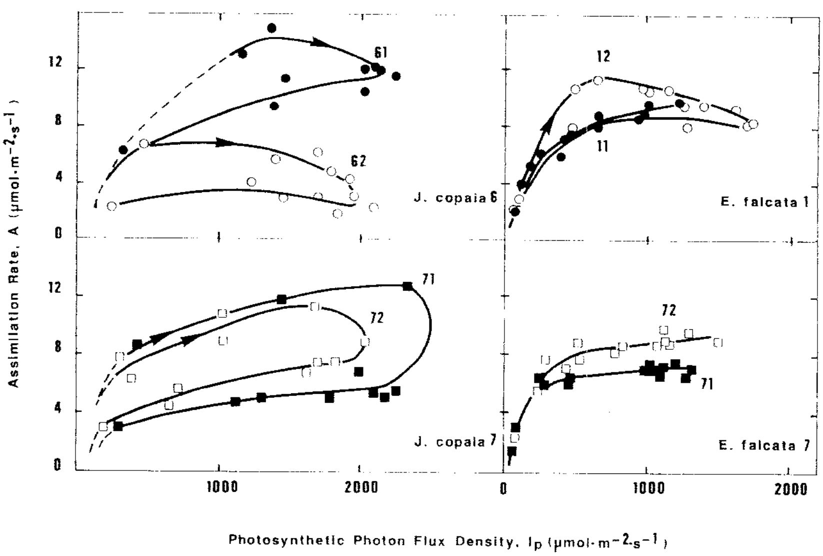

Fig. 1. Diurnal changes of CO_2 assimilation rate against photosynthetic photon flux density in 4 leaflets from 2 *J. copaia* and 2 *E. falcata* trees. September 10, 1987. The measurements were made on leaflets in their natural orientation.

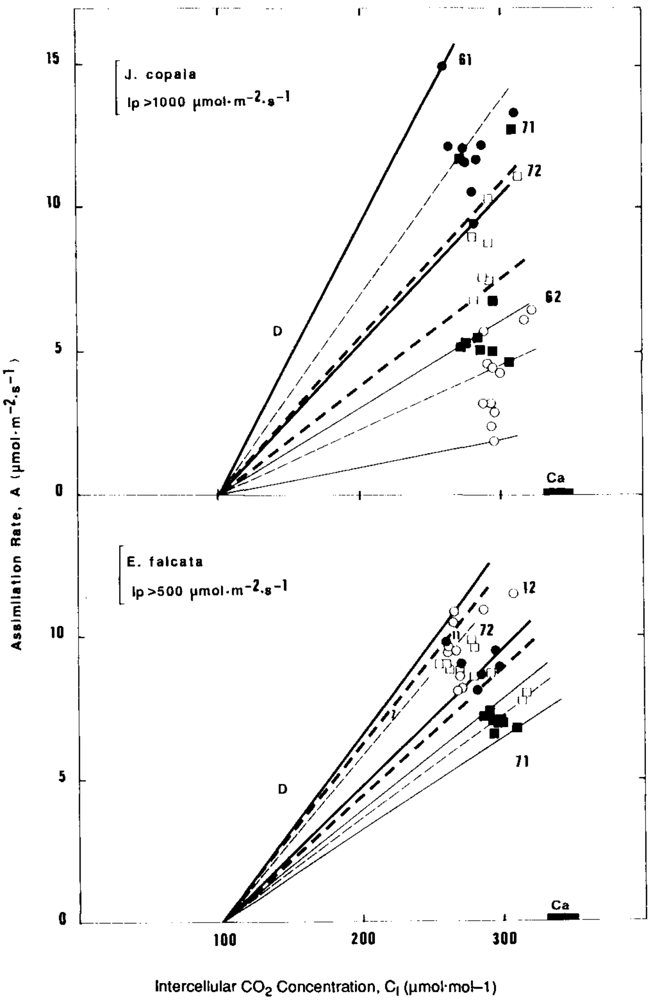

Fig. 2. Diurnal changes of CO_2 assimilation in relationship with calculated intercellular CO_2 concentration in 4 leaflets from 2 *J. copaia* and 2 *E. falcata* trees. The extreme demand functions *(D)* are represented by 2 lines for each leaflet. C_a: ambient CO_2 concentration. September 10, 1987.

Surprisingly, in the present study, the typical forest species *E. falcata* exhibited greater drought adaptation features than the pioneer *J. copaia.* This might be of major importance for the choice of appropriate species for reforestation.

References

Doley D., Yates D.J. & Unwin G.L. (1987) Photosynthesis in an Australian rain forest tree. *Argyrodendron peralatum,* during the rapid development and relief of water deficits in the dry season. *Oecologia (Berlin)* 74, 441-450

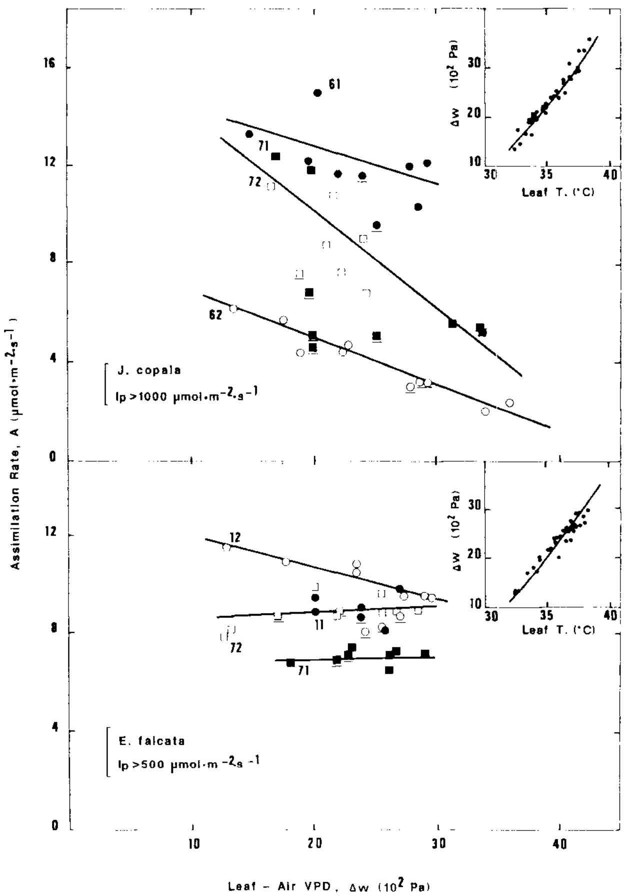

Fig. 3. Diurnal changes of CO_2 assimilation rate in 4 leaflets from 2 *J. copaia* and 2 *E. falcata* trees against leaf-to-air vapor pressure difference. Data points are measurements with increasing Δw in the morning (plain symbols) and with decreasing Δw in the afternoon (underlined symbols). Insets show the relationships between leaf temperature and Δw. September 10, 1987.

Grieu P., Guehl J.M. & Aussenac G. (1988) The effects of soil and atmospheric drought on photosynthesis and stomatal control of gas exchange in three coniferous species. *Physiol. Plant.* 73, 97-104

Jones H.G. (1985) Partitioning stomatal and non-stomatal limitations to photosynthesis. *Plant Cell Environ.* 8, 95-104

Küppers M., Matyssek R. & Schulze E.D. (1986) Diurnal variations of light saturated CO_2 assimilation and intercellular carbon dioxide concentration are not related to leaf water potential. *Oecologia (Berlin)* 69, 477-480

Schulze E.D, Lange O.L., Everani M., Kappen L. & Buschbom U. (1974) The role of air humidity and leaf temperature in controlling stomatal resistance of *Prunus armeniaca* L. under desert conditions I. A simulation of the daily time course of stomatal resistance. *Oecologia* 17, 159-170

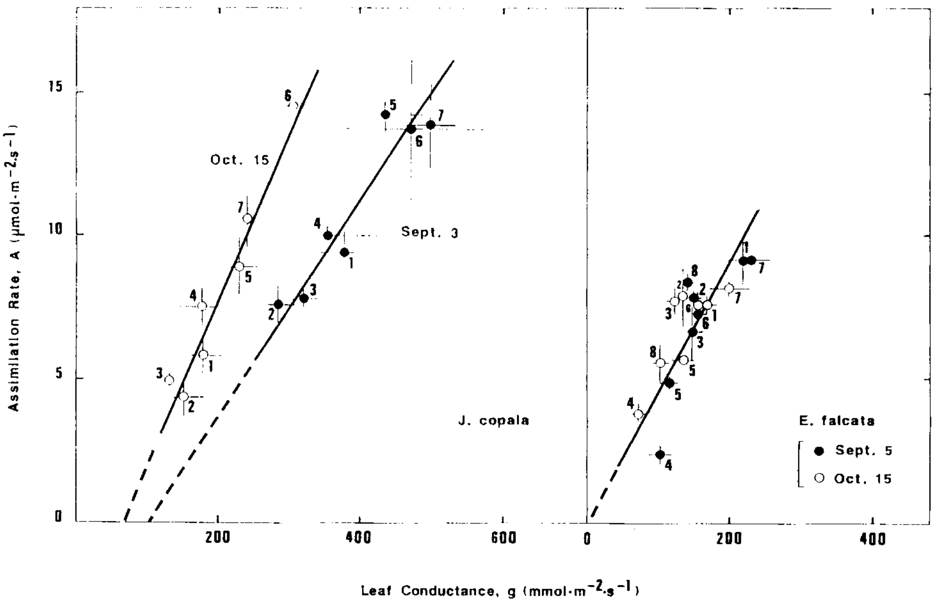

Fig. 4. Relationships between leaf conductance and CO_2 assimilation rate in *J. copaia* and *E. falcata* at the beginning (September 3 and 5), and in the middle (October 15), of the dry season 1987. Data points represent different trees and correspond to the means of 4 replicates (leaflets) ± 1 SEM unless it lies within the plotted symbol.

Tenhunen J.D., Pearcy R.W. & Lange O.L. (1987) Diurnal variations in leaf conductance and gas exchange in natural environments. *In: Stomatal Function* (Zeiger E., Farquhar G.D. & Cowan I.R., eds.), Stanford University Press, Stanford, pp. 323-351