Field studies of leaf gas exchanges in oil palm tree
(*Elaeis guineensis* Jacq.)

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Introduction

This study is part of a larger research program on climatic and biological factors affecting oil palm yield. Our purpose was to characterize, under conditions of good water supply, variations in leaf photosynthesis with internal and external factors.

Several authors have been working on the CO₂ assimilation rate (*A*) in oil palm. Most of them have used young plants under laboratory conditions to study effects of photosynthetically active radiation (Corley *et al.*, 1973; Hirsch, 1975), foliar temperature (Hong and Corley, 1976) or leaf water potential and stomatal conductance (Adjahossou, 1983). Only 2 experiments were conducted in the field: Bolle-Jones (1968) determined the amount of soluble sugars in 9 yr old leaflets and Corley (1983) observed the effects of leaf senescence on photosynthesis using the $^{14}$CO₂ method.

In this study, we evaluated variations in leaf photosynthesis in 8 trees of the same progeny, and the effect of vapor pressure deficit ($VPD = e_s (T_d) - e_a$) and leaf temperature ($T_l$) on stomatal conductance and leaf gas exchanges.

Materials and Methods

The study site was located at the I.R.H.O.¹/C.I.R.A.D.² experimental station of La Mé near Abidjan, Ivory Coast (5°26'N Lat., 3°50'W Long.). The studied trees belong to one single line (L2T*D10D) used as a reference in many trials of the production area and characterized by a moderate vegetative development associated with good bunch production.

The net CO₂ assimilation rate (*A*) was measured using a leaf chamber (PLC, A.D.C.³) and a portable CO₂ analyzer (LCA2, A.D.C.) connected in an open system. Leaf temperature, transpiration rate, boundary layer and stomatal conductances were calculated using the energy balance equation (Parkinson, 1985) combined with standard equations (von Caemmerer and Farquhar, 1981).

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Results

Fig. 1 shows measurements made on the 8th or 9th leaf of 8 different palm trees (last leaf fully opened is numbered 1). Light was the only limiting factor. Relative error of measurements in low light was too high to allow a comparison of apparent quantum yield between trees.

Maximal leaf assimilation rates (PAR higher than 1100 \( \mumol \cdot m^{-2} \cdot s^{-1} \)) were not significantly different between trees \((F = 1, dF = 52)\).

The maximal \( CO_2 \) assimilation rate decreased with leaf age in 10 yr old oil palm (Fig. 2). This decrease became more pronounced at leaf number higher than 25 (= 2 yr old), when maximal stomatal conductance was also decreasing.

The net \( CO_2 \) assimilation rate was slightly sensitive to VPD increase up to 1.7 kPa, and then it dropped steadily (Fig. 3a). The transpiration rate decreased linearly with VPD because of rapid stomatal closing (Fig. 3a, b). There was no change in the \( CO_2 \) assimilation rate as a result of changes in leaf temperature (Fig. 3c). The transpiration rate and stomatal conductance increased with leaf temperature (Fig. 3c, d).

Discussion and Conclusion

The maximal photosynthesis observed in 5 yr old oil palm \((A = 23.70 \mu mol \cdot m^{-2} \cdot s^{-1})\) was not very different from Corley's (1983) results \((A = 20 \mu mol \cdot m^{-2} \cdot s^{-1}, 3 \text{ yr old trees, leaf number 10})\). This high \( CO_2 \) assimilation rate is quite similar to those of fast growing temperate trees, such as \textit{Populus sp.} (Ceulemans et al., 1987) and slightly higher than those of wet tropical forest and crop trees (Mooney et al., 1984). Leaf temperature between 30 and 38°C had no effect on photosynthesis which shows an adaptation to high temperatures in this tropical \( C_3 \) species.

Observed stomatal opening with increases in temperature is a classical response that is often concealed by a simultaneous variation in VPD (Jarvis and Morison, 1981). When VPD increases above about 1 kPa, it causes a rapid stomatal closure that induces a decrease in the transpiration rate, despite a high eva-
porative demand. Stomatal sensitivity to VPD has been reported in numerous spe-
cies (Farquhar et al., 1980; El Sharkawy et al., 1984). It is especially pronounced in
oil palm and confers good survival capability to overcome drought to this spe-
cies but strongly reduces bunch produc-
tion.

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Fig. 3. Rate of transpiration (E), rate of CO₂ uptake (A), and stomatal conductance (gₛ), versus vapor pressure
deficit (a and b) and, leaf temperature (c and d) with VPD varying from 1 to 1.8 kPa.


