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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 CO_2 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 $^{14}CO_2$ method.

In this study, we evaluated variations in leaf photosynthesis in 8 trees of the same progeny, and the effect of vapor pressure deficit ($VPD = e_s\ (T_a) - e_a$) and leaf temperature (T_f) 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 CO_2 assimilation rate (A) was measured using a leaf chamber (PLC, A.D.C.[3]) and a portable CO_2 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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[1] I.R.H.O.: Institut de Recherche sur les Huiles et les Oléagineux.
[2] C.I.R.A.D.: Centre de Coopération International en Recherche Agronomique pour le Développement.
[3] A.D.C.: Analytical Development Company.

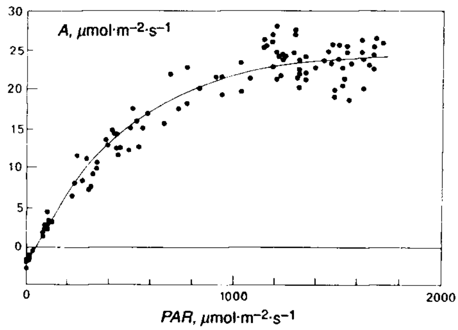

Fig. 1. Rate of CO_2 uptake *(A), versus* incident photosynthetically active radiation *(PAR)*, in young leaves (8 trees). *VPD* lower than 0.4 kPa, T_f varies from 29 to 37°C and g_s higher than 9 mm·s^{-1}.

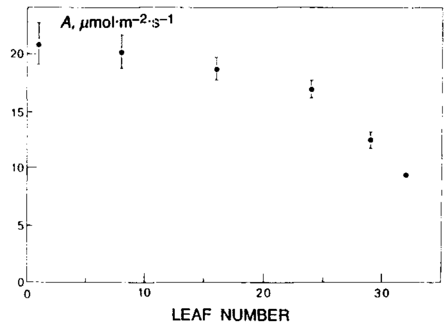

Fig. 2. Response to changes in leaf age of maximal assimilation rate *(A)*. *PAR* higher than 1100 mol·m^{-2}·s^{-1}.

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 µmol·m^{-2}·s^{-1}) were not significantly different between trees ($F = 1$, d$F = 52$).

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 µmol·m^{-2}·s^{-1}) was not very different from Corley's (1983) results (A = 20 µmol·m^{-2}·s^{-1}, 3 yr old trees, leaf number 10). This high CO_2 assimilation rate is quite similar to those of fast growing temperate trees, such as *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-

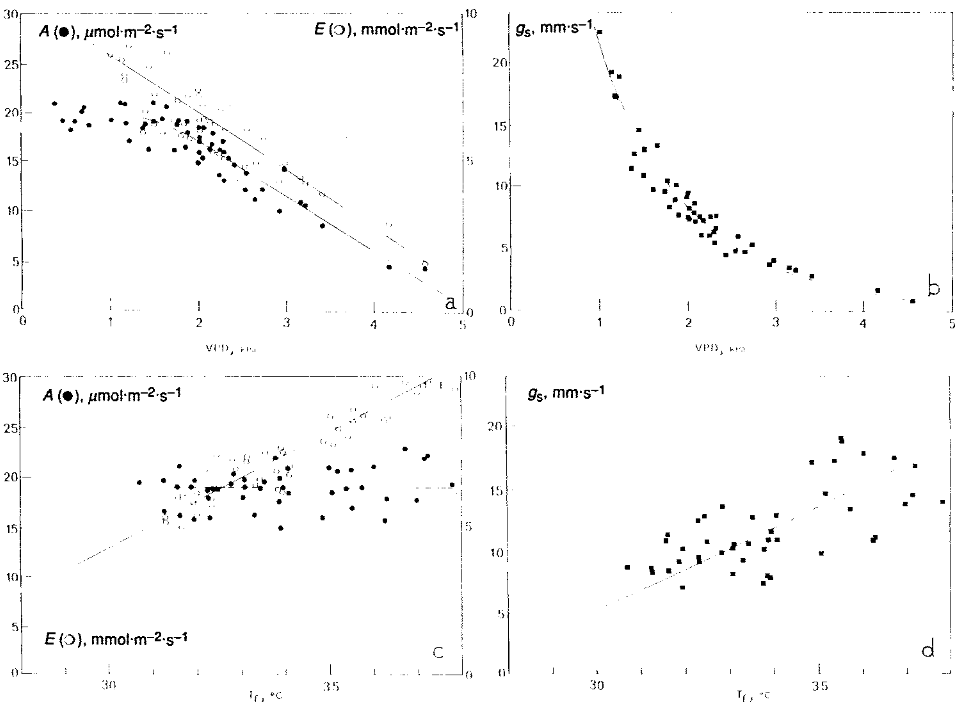

Fig. 3. Rate of transpiration (*E*), rate of CO_2 uptake (*A*), and stomatal conductance (g_s), *versus* vapor pressure deficit (**a** and **b**) and, leaf temperature (**c** and **d**) with *VPD* varying from 1 to 1.8 kPa.

porative demand. Stomatal sensitivity to *VPD* has been reported in numerous species (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 species but strongly reduces bunch production.

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