Leaf Gas Exchanges of Oil Palm Under Soil Water Variation in For Different Ecologies : Modelling Comparisons

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The objective of the study is to compare three classical models of stomatal conductance from Ball et al, Leuning, and the Lloyd's one in relation with the water content of the top soil estimated with the water balance model of Dufrên. Four agroecological zones which were used : La Mé (Ivory Coast), Pobé (Republic of Benin), Marihat (North Sumatera), Lampung (South Sumatera) and the respective period of each leaf gas exchange measurement present for this study an interesting scale of edaphic conditions for oil palm. Leaf gas exchange measurement have been done with the LCA2 (ADC England) in La Mé (Ivory Coast) on the control family LM2T x DA10D during Feb/April/Oct/Nov 1987, in Pobé on three clones (parent : LM10T x DA17D, LM10T x DA8D, LM10T x DA118D, plot 426/447, 1988) during Oct/Dec 1992, in Marihat (North Sumatera) on three clones during Feb/May 1994 and in Bekri (Lampung, South Sumatera) on three clones during September 1997. From the estimation of AWC (available water of the soil) with the water balance model of Dufrêne, it is possible to establish a very simple linear regression with observed values of stomatal conductance. This may be a good empirical base for coupling carbon and water balance model for oil palm, with the condition to calibrate precisely the water balance for larger soil scale.

Leaf gas exchange of oil palm under soil water variations in four different ecologies: modelling comparisons

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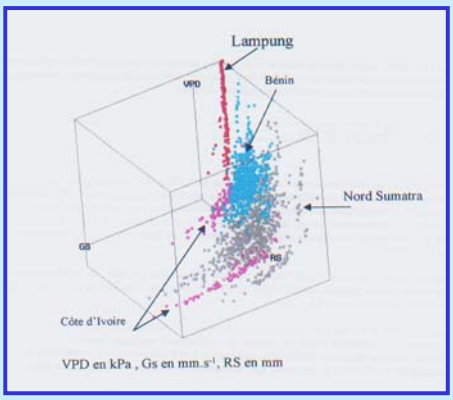
INTRODUCTION

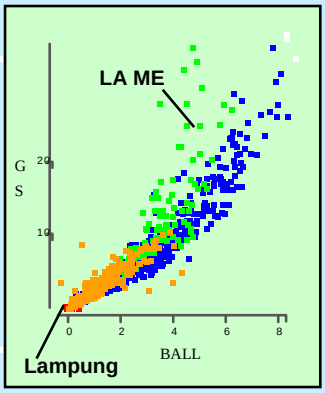
The leaf photosynthesis of the oil palm is very sensitive to environmental conditions as the vapour pressure deficit (1) and also to the soil water conditions (2). The stomatal conductance is a very pertinent integrating variable of both environmental factors. For many species, the relation between the leaf photosynthesis and the stomatal conductance is very well documented (3) and similar observation have been done for oil palm (4). The general aim of this present work is to compare three classical models of stomatal conductance from Ball et al (5) , Leuning (6) and the Lloyd's (3) one in relation with the water content of the top soil estimated with the water balance model of Dufrêne (1,2). The four agroecological zones which are concerned:La Mé (Ivory Coast, Pobè (Republic of Benin), Marihat (North Sumatra), Lampung (South Sumatra) and the respective period of each leaf gas exchange measurement present for this study an interesting scale of edaphic conditions for oil palm.

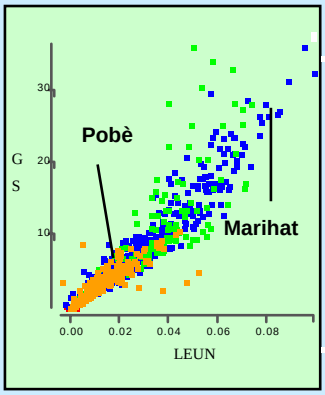
MATERIALS AND METHODS

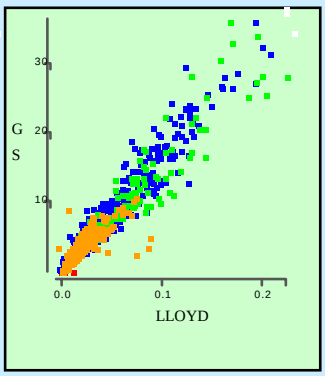
All leaf gas exchange measurements have been done with an open system with the LCA2 (ADC England) in La Mé (Ivory Coast) on the control family LM2T x DA10D (cf Dufrêne (7)) during Feb/April/Oct/Nov87, in Pobè (SRPH. Benin) on 3 clones (parent : LM10T x DA17D,LM10Tx DA8D, LM10T x DA118D, plot 426/447, 1988) Oct/Dec 92,in Marihat (North Sumatra) on 3 clones (cf Lamade & Setiyo (8)) in Fev/May 94 and in Bekri (Lampung, South Sumatra) on 3 clones(cf Lamade et al. (9)) during september 1997. The water balance of Dufrêne were used with in input daily meteo data (Pobè: monthly only) and AWC, ETR, ETP were estimated for each measuring day of stomatal conductance and net photosynthesis.All calculations have been proceeded with the SAS system 6.12.

	La Mé	Pobè	Marihat	Lampung
N	180	738	813	161
AWC mm	341.46(estimated)	296.9	405.47	171.33
s.d.	81.89	33.47	57.77	0.51
ETR/ETP	0.79(measured)	0.67	0.86	0.09
s.d.	0.08	0.1	0.08	0.0003
Gs mm.s-1	12.25(measured)	3.73	9.52	0.518
s.d.	7.09	1.73	5.62	0.65
NP µmol.m-2.s-1	13.03(measured)	7.33	14.26	1.15
(measured)	6.75	4.1	7.79	6.92









gs in mm.s^{-1}, Index of :
Ball = NP*RHs/CO_2s
Leun = NP/((CO_2s-ϒ)*(1+VPD))
Lloyd = NP/((VPD*(ci- ϒ))
(with only gs when par >900 µmol.m^{-2}.s^{-1})
CO_2s: concentration around the leaf surface

ci : substomatal concentration of CO_2
RHs : relative humidity around the leaf surface
ϒ : compensation point for CO_2

		LA ME	POBE	MAR.	LAMPUNG
Ball	df	1 07	273	420	10
	r2	0.57	**0.68**	0.86	n.s.
	Fisher	145***	**596*** **	2769***	
Leun	r2	0.52	0.64	0.90	n.s.
	Fisher	117***	498***	3844***	
Lloyd	**r2**	**0.83**	0.59	**0.91**	n.s.
	Fisher	**554*** **	392***	**4613*** **	

N.B. *The water balance model used in this work is only calibrated for sandy soil in Ivory Coast conditions.*

Relation Gs and AWC :
regression coefficient (0.04), intercepted (-6.81)R2 = 0.37***, Fisher test=1122.*** (significant P<0.0001) df=1890,

N : number of observations,
AWC : available water of the soil,
ETR : evapo-transpiration,
ETP : potential evapotranspiration ,
Gs : stomatal conductance,
NP : net photosynthesis.
s.d. : standard deviation.

RESULTS AND CONCLUSION

These three empirical models are all able to describe significantly the strong relation between the net photosynthesis and the stomatal conductance for the oil palm in a large scale of water conditions excepted for very dry conditions as in Lampung in 1997. The Lloyd 's model gives a better fitting for good conditions in La Mé and in Marihat whereas the Ball's one shows a better fitting for drier conditions in Pobè. From the estimation of AWC with the water balance model of Dufrêne (1,2), it is possible to establish a very simple linear regression with observed values of stomatal conductance.This may be a good empirical base for coupling carbon and water balance model for oil palm, with the condition to calibrate precisely the water balance for larger soil scale.

REFERENCES

(1) Dufrêne, 1989.PHDThesis, France.
(2) Dufrêne et al. 1992. Acta Oecologica 13(3)
(3) Lloyd.1991.Plant Physiol.18.
(4) Lamade et al.1996.PIPOC. Malaisia.
(5) Ball et al. 1987.Ed Biggins. Netherlands.
(6) Leuning, 1995. Plant, Cell and Environment, 18
(7) Dufrêne & Saugier. 1993. Functionnal Ecology. 7
(8) Lamade & Setiyo . 1997 .PRD.CIRAD.
(9) Lamade et al. 1998. ISOPB. Bali.

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