THE USE OF PLANT ARCHITECTURAL MODELS FOR ESTIMATING RADIATION TRANSFER WITHIN AGROFORESTRY SYSTEMS :

AN EXAMPLE FOR MULTI-STRATA COCONUT-BASED FARMING SYSTEMS

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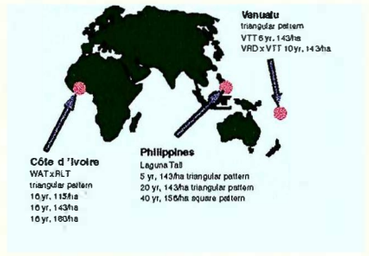
INTRODUCTION

In many multi-strata agroforestry systems, transmitted photosynthetically active radiation (PAR) can be an important limiting factor for the establishment and growth of intercrops. Knowledge of the radiative climate under a given stand according to age, planting density and planting pattern is therefore of major interest for the management of multi-strata coconut-based farming systems.

23-month-old *Theobroma cacao* (hybrid mixture) at 960/ha under 8-year-old *Cocos nucifera* (hybrid PB121) at 160/ha in Indonesia

MATERIALS AND METHODS



1: Plant material: *Cocos nucifera* varieties and planting pattern

3: Computer image of a multi-strata stand of *Theobroma cacao* and *Cocos nucifera*

SUMMARY

1: Experiments were conducted on several varieties of coconut (*Cocos nucifera* L.) and on cocoa (*Theobroma cacao* L.) in Côte d'Ivoire, Philippines, Vanuatu.

2: The architecture of *a)* coconut and *b)* cocoa was described and modelled according to botanical concepts.

3: Virtual coconut stands were built for computation of interception, spatial distribution, multiple scattering, total radiative balance.

4: Radiative climate was measured under real coconut stands and simulated under virtual stands.

5: Radiative climate simulations were validated under coconut stands in a large range of conditions.

6: The spatial distribution of light reaching the ground under a coconut stand was mapped.

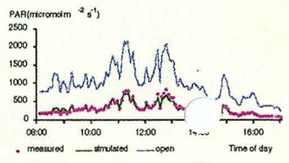
7: PAR intercepted by cocoa was simulated under virtual coconut stands.

8: On the basis of field measurements, it was possible to forecast yield of annual intercrops in relation to light transmitted by the coconut stand.

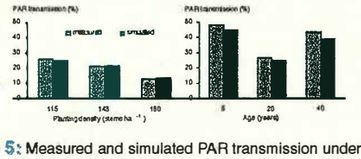
9: In the present experiment, yield of cocoa was also related to light.

2: Building 3-D numerical mock-ups of *Cocos nucifera* (left) and *Theobroma cacao* (right)

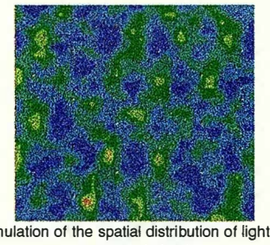
RADIATION SIMULATION AND VALIDATION



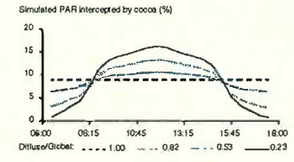
4: Example of PAR transmitted under 10-yr-old coconut at 143/ha and in the open (Vanuatu)



5: Measured and simulated PAR transmission under coconut, according to planting density (left, Côte d'Ivoire) and to age (right, Philippines)

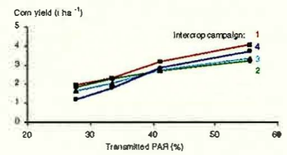


6: Simulation of the spatial distribution of light under a coconut stand

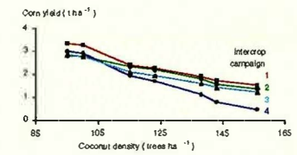


7: Simulation of intercepted PAR by a cocoa stand, according to external conditions (Vanuatu)

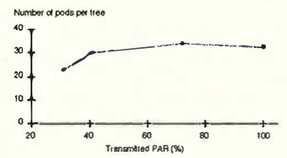
FORECASTING YIELD



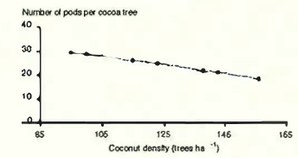
8a: Experimental response curve of corn yield against average daily PAR value (Philippines)



8b: Forecasted corn yield under 20-yr-old coconut in the Philippines



9a: Experimental yield of cocoa under different artificial shading conditions (Vanuatu)



9b: Forecasted yield of cocoa under a 20-yr-old coconut stand

DISCUSSION & CONCLUSIONS

✔ A good agreement was obtained between estimated PAR and field measurements.
✔ By using three-dimensional numerical mock-ups, transmitted radiation can be estimated accurately.
✔ By combining experimental yields with radiation simulations, it was possible to predict yield of annual intercrops, in the absence of water deficit and nutrient competition.
✔ Although in the present experiment of intercropping between coconut and cocoa, light appeared to be a limiting factor, it would be hazardous to generalise this result : early observations have shown that some architectural features of young cocoa can be influenced by the amount of shading, exhibiting differences between monoculture and intercropping conditions.
✔ Further studies are now under way to link these architectural characteristics to light conditions and to better understand yield responses to light.