Toward a functional-structural model of oil palm able to assist the evaluation of genetic differences between progenies for architecture and radiation interception efficiency

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5th International Conference on Oil Palm and Environment (ICOPE)
Nusa Dua Bali, 16 - 18 March 2016

Toward a functional-structural model of oil palm

Evaluation of genetic differences between progenies for architecture and radiation interception efficiency

R. Perez [1,2], J. Dauzat [1], B. Pallas [2], H. Rey [1], G. Le Moguédec [3], S. Griffon [1], J.P. Caliman [4] and E. Costes [2]

Context & Objectives

Find more sustainable and productive systems is a major challenge to fulfil increasing vegetable oil demand, including palm oil. Tackling climate changes requires bold and swift actions such as breeding of well suited plant material and implementation of innovative growing practices. But, to this end, we need sound bases of what ideotypes must be for the future and what the proper practices should consist in. For addressing these questions, functional-structural modelling approach (FSPM) enables to explore the relationships between 3D structure of plants with their physiological functioning in relation to weather conditions, with the possibility to simulate virtual management practices such as clearing and pruning. The main assumption underlying this project is the possibility to enhance potential oil palm production optimizing plant architecture in relation to radiation use efficiency. The present study investigates two aspects of a FSPM study applied to oil palm: i) characterize architectural variability and reconstruct three-dimensional (3D) mock-ups of oil palm and ii) estimate light interception efficiency of different oil palm progenies from virtual stands.

Material & Methods

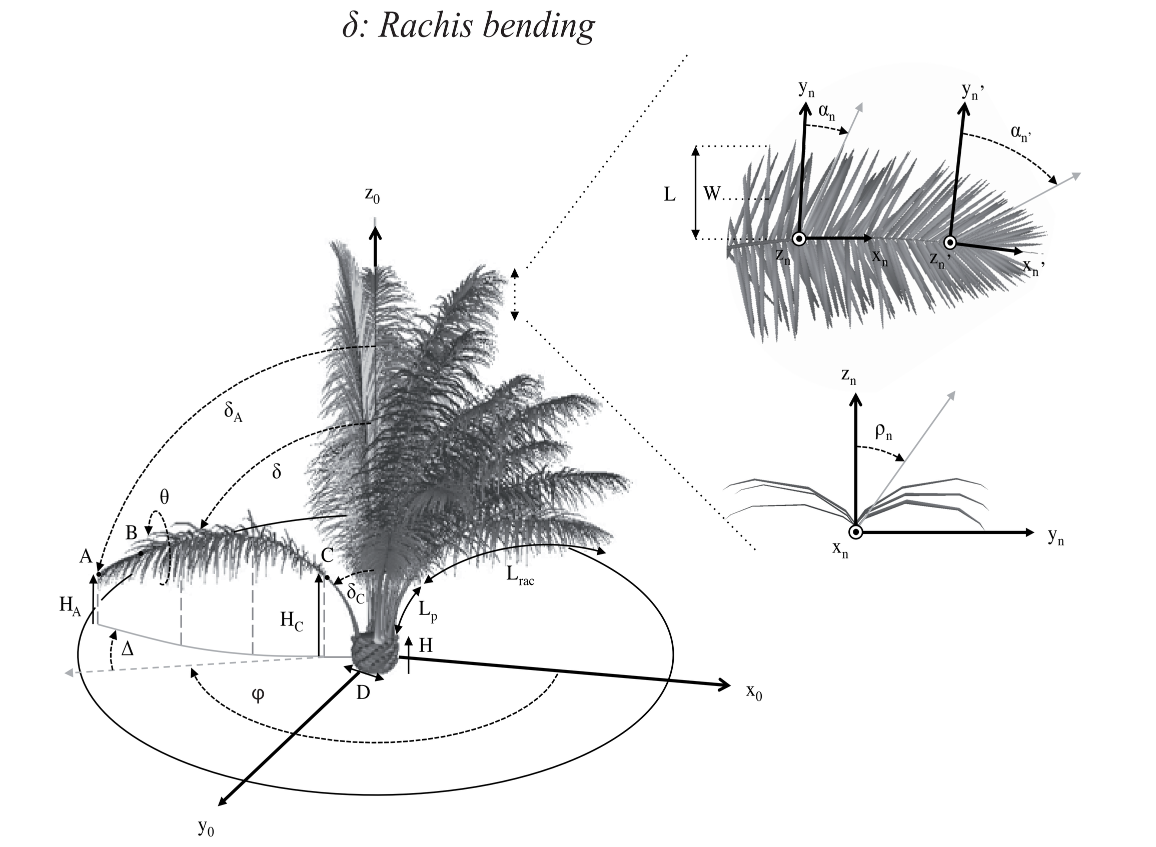
Material and site

Reference	Progeny	Origin	Characteristics
DA1	Deli x Avros	South East Asia	Large vegetative development
DL7	Deli x La Mé	Africa	Low vegetative development High yield
DS	Deli x (La Mé x Sibiti)	Africa	Medium vegetative development Medium yield
DU	Deli x Unkown	Africa	Medium vegetative development Drought tolerance
DY4	Deli x Yangambi	Africa	Medium vegetative development Medium yield

- Material planted on 2010
- SMARTRI experimental plots (South Sumatra)

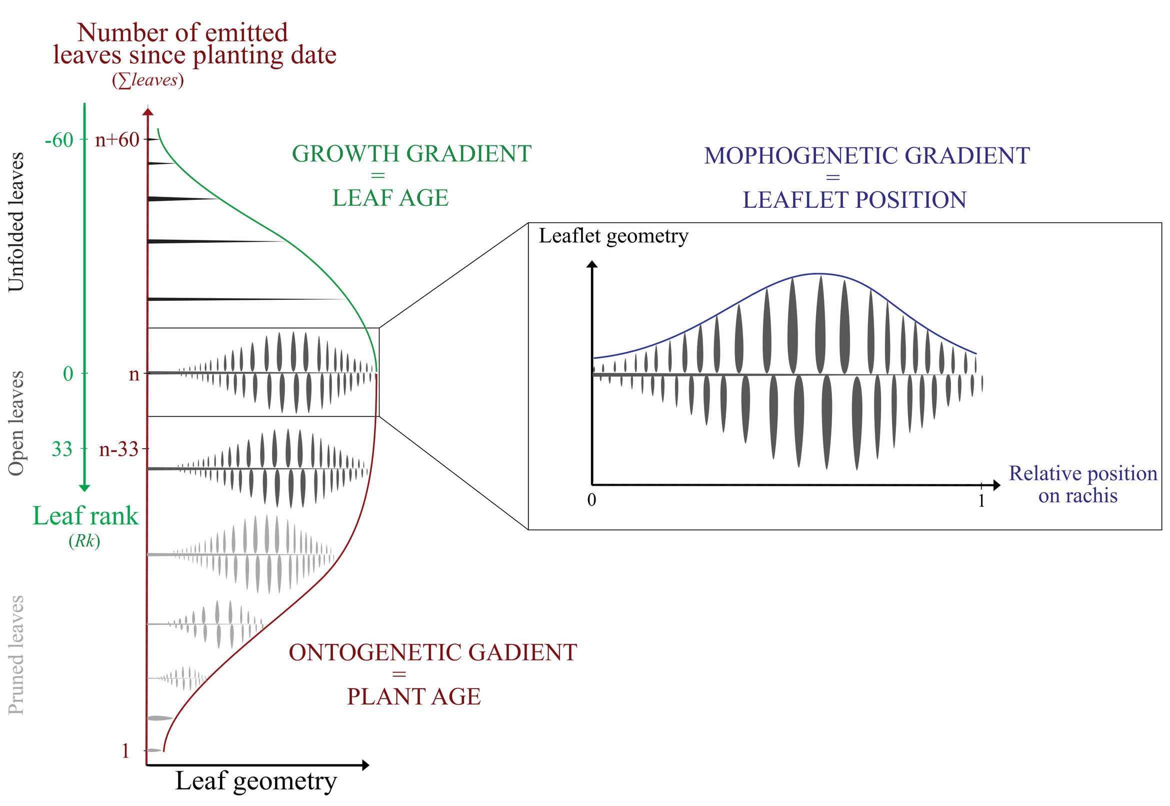
Field observations

Plant Scale	Leaf scale	Leaflet scale
H: Stem height	*L_p: Petiole length*	*L: Leaflet length*
D: Stem diameter	*L_{rac}: Rachis length*	*W: leaflet width*
Φ: Phyllotaxy	*Δ: Rachis deviation*	*α: Leaflet axial angle*
	θ: Rachis twist	*ρ: Leaflet radial angle*
	δ: Rachis bending	



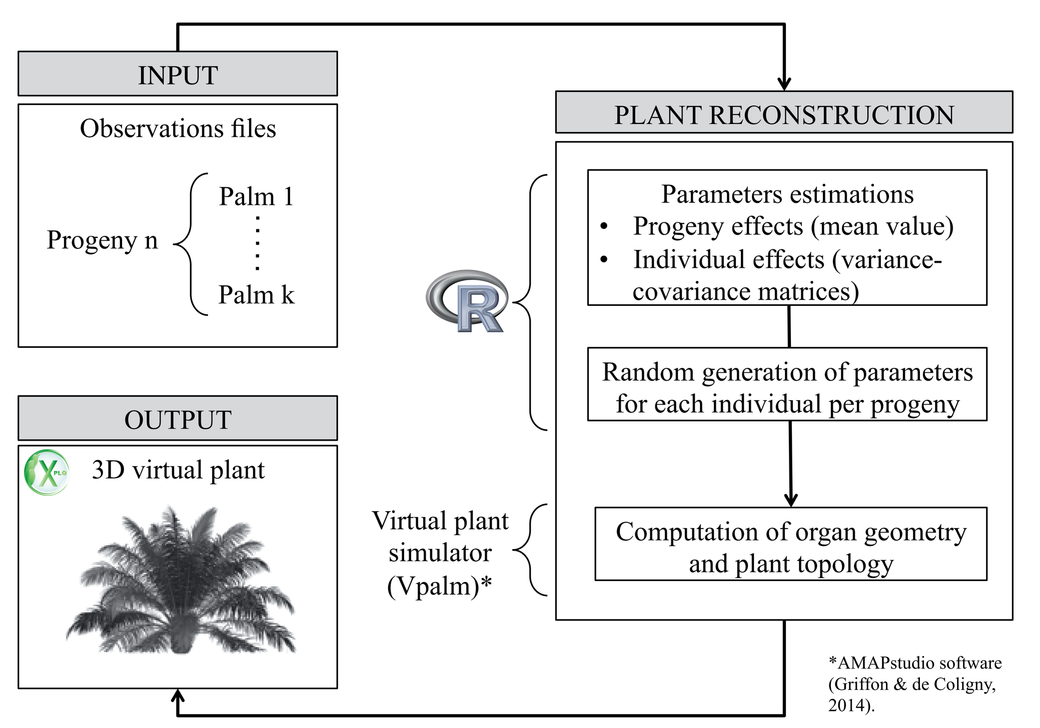
Allometric-based approach

Modelling ontogenetic and morphogenetic gradients with temporal and spatial variables



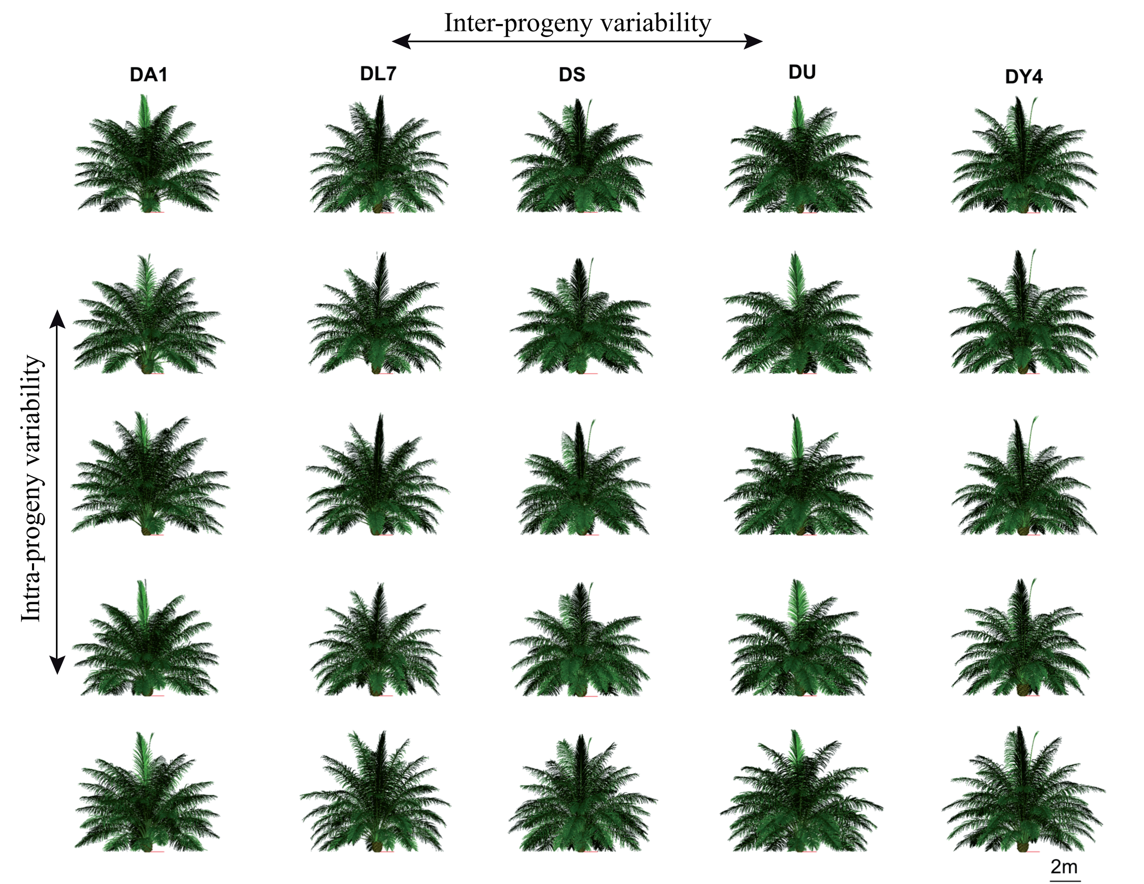
Strategy for reconstructing 3D palm mock-ups

Integration of mixed-effect models to represent inter and intra progeny variability



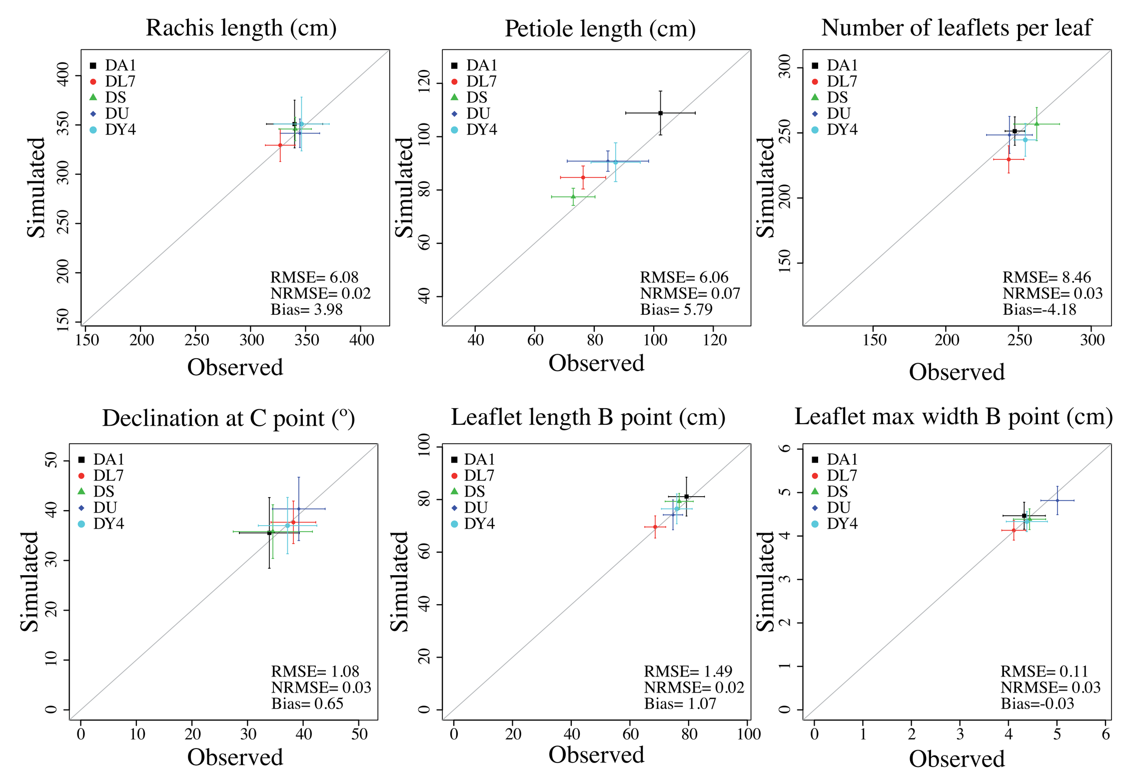
Results

Rendering inter and intra-progeny variability



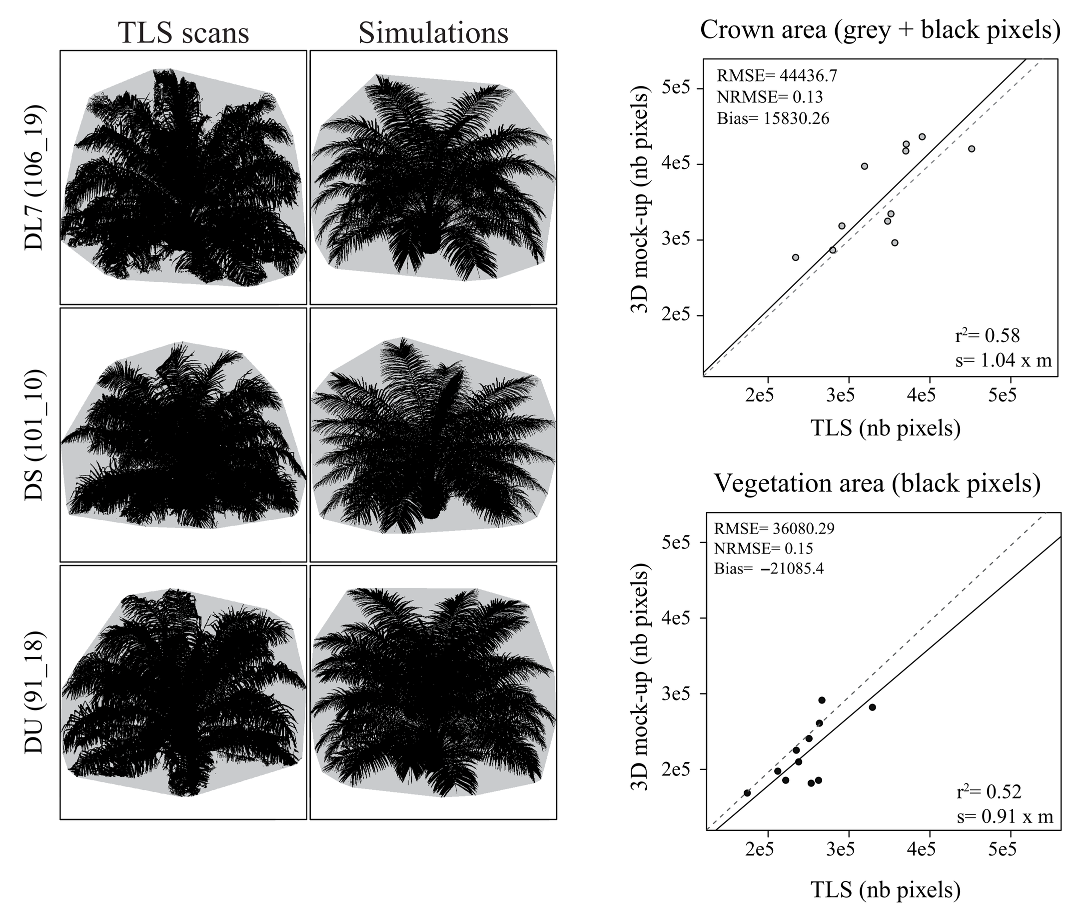
Evaluation of model compliance with field observations

Simulated vs. observed mean and variances of architectural traits



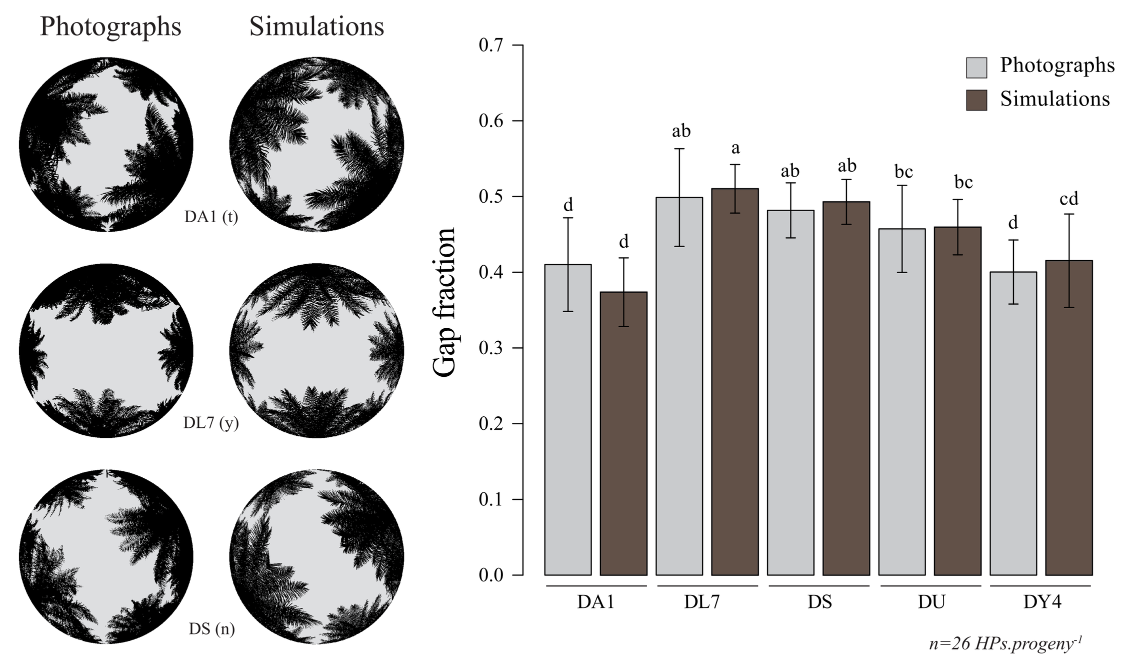
Validation at individual scale with terrestrial laser scans (TLS)

Comparison of TLS acquisitions with simulations on 3D mock-ups



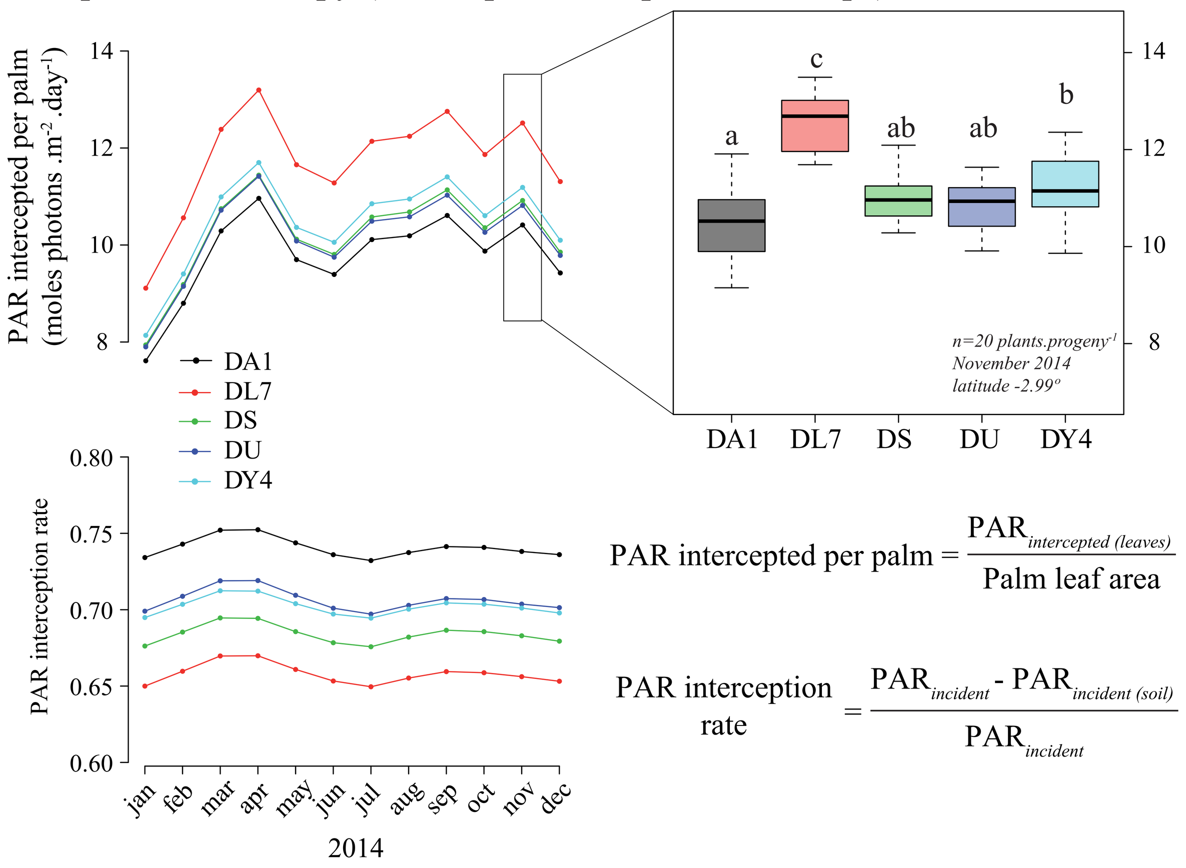
Validation at plot scale with hemispherical photographs (HPs)

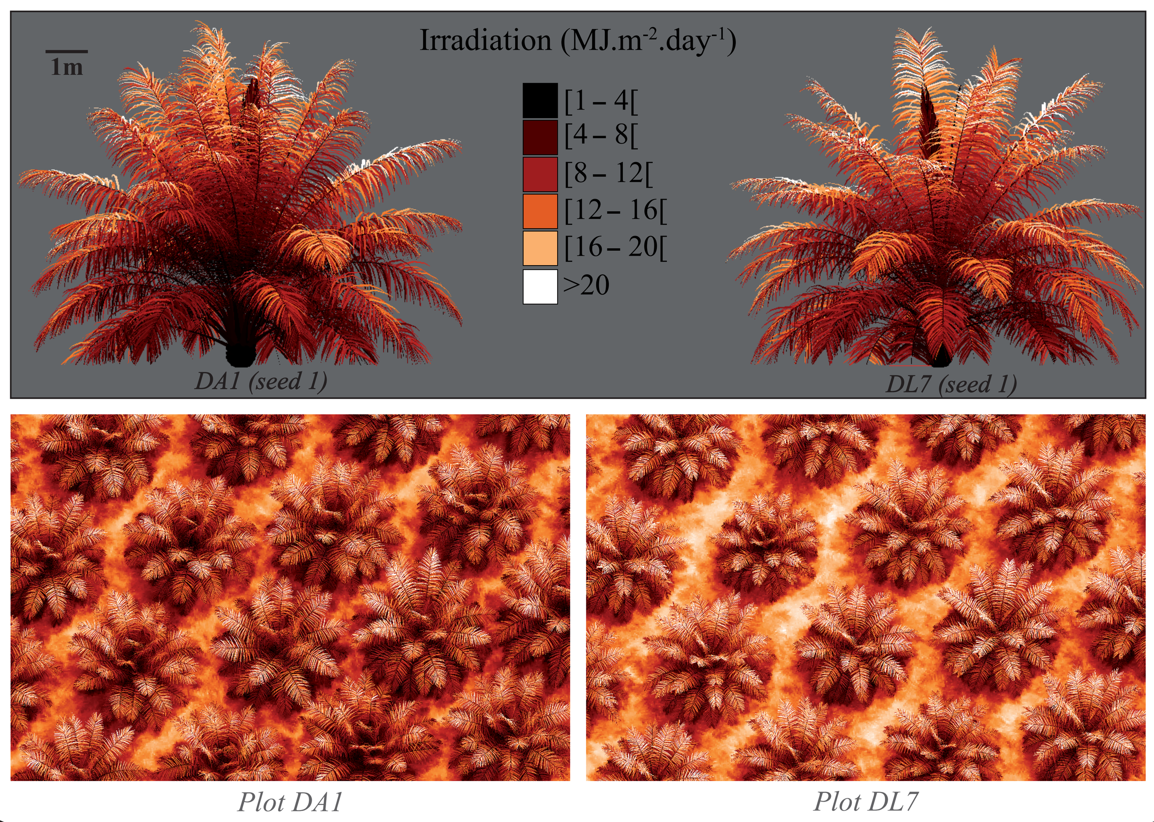
Comparison of gap fraction from camera HPs and virtual HPs



Comparison of progenies in respect to light interception over seasons

Simulation of photosynthetically Active Radiation (PAR) intercepted by palms and canopy (virtual plot of 20 palm mock-ups)





Conclusions

- Studied progenies exhibit significantly different architectural traits
- Model correctly renders inter and intra progeny architectural variability
- Virtual experiments highlight contrasting light interception efficiency between the studied progenies

Perspectives

- Identify key architectural traits affecting light interception efficiency
- Interface the calculation of light interception with photosynthesis and stomatal regulation
- Define varietal ideotype and propose new phenotypic traits for breeding trials
- Perform *in silico* experiments to test new agronomic practices

References

Dauzat, J., Clouvel, P., Luquet, D., and Martin, P. (2008). Using virtual plants to analyse the light-foraging efficiency of a low-density cotton crop. Annals of Botany, 101(8):1153–1166.

Griffon, S. and de Coligny, F. (2014). Amap-studio: An editing and simulation software suite for plants architecture modelling. Ecological Modelling, 290:3–10. Special Issue of the 4th Inter- national Symposium on Plant Growth Modeling, Simulation, Visualization and Applications (PMA'12) Special Issue of PMA'12.

Pallas B., Soulie J.-C, Aguilar G., Rouan L., and Luquet D. X-palm, a functional structural plant model for analysing temporal, genotypic and inter-tree variability of oil palm growth and yield. 7th International Conference on Functional-Structural Plant Models. Saariselk a, Finland, June 2013.

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