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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**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 pruning 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

#### Field observations

<table>
<thead>
<tr>
<th>Plant Scale</th>
<th>Leaf scale</th>
<th>Leaflet scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (H)</td>
<td>Petiole length (L1)</td>
<td>Leaflet length (L)</td>
</tr>
<tr>
<td>Stem diameter (D)</td>
<td>Rachis length (L2)</td>
<td>Leaflet width (W)</td>
</tr>
<tr>
<td>Phylosusy (Φ)</td>
<td>Rachis deviation (α)</td>
<td>Leaflet axial angle (θ)</td>
</tr>
<tr>
<td>Rachis twist (τ)</td>
<td>Rachis bending (β)</td>
<td>Leaflet radial angle (γ)</td>
</tr>
</tbody>
</table>

#### 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

#### Rendering inter and intra-progeny variability

<table>
<thead>
<tr>
<th>Material and site</th>
<th>Interprogenetic variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR interception</td>
<td>PAR intercepted per palm</td>
</tr>
</tbody>
</table>

#### 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

### Results

#### 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

