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Modelling architectural traits of oil palm progenies and their effect on light interception at plant and stand scales

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The development of new strategies to find more sustainable and productive systems is a major challenge to fulfil increasing vegetable oil demand, including palm oil. Breeding has largely contributed to improve oil palm productivity, but so far, selection mainly focussed on yield components (e.g. number of bunches, number of fruits per bunch or oil content in fruits). The main statement underlying this study is the possibility to enhance potential crop production by optimizing plant architecture in relation to radiation use efficiency.

To this end we developed a model for simulating the 3D architecture of oil palms from morphometric and geometric measurements. Allometric relationships were subsequently designed to simulate the morphogenetic gradients of architectural traits within the crown at leaf and leaflet scales. The methodology allowed reconstructing virtual oil palms at different stages over plant development. Additionally, the allometric-based approach was coupled to mixed model effect in order to integrate inter and intra progeny variability through progeny-specific parameters. The model thus enabled to simulate the specificity of plant architecture for a given progeny while including inter-individual variability. The AMAPstudio software (Griffon & de Coligny, 2014) was used to generate populations of 3D virtual palms for estimating light interception efficiency of 5 progenies, from individual scale to stand scale. A sensitivity analysis was then performed on the architectural parameters to evaluate their impact on light interception efficiency.

Results pointed out the capacity of our modelling approach to generate realistic 3D mock-ups considering the architectural specificities of the studied progenies. Simulations revealed distinct light interception efficiency among the progenies all along plant development. Given these results, sensitivity analyses were performed and enabled to highlight key architectural traits governing light interception (density of leaflets on rachis, rachis curvature and leaflets morphology). Such work paves the way on the identification of ideotype by combining appropriate architectural traits to optimize light interception efficiency under specific climatic environment. Forthcoming work will be dedicated to interface the calculation of light interception with carbon assimilation to better estimate the trades-off between plant architecture and plant production.

Keywords: 3D reconstruction of plant architecture, genetic variability, light interception, sensitivity analysis, morphological ideotype traits.