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Simulating pruning responses in a 3D model of cocoa trees

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Introduction

- Pruning is a recommended potentially yield-enhancing practice in cocoa cultivation.
- The impact of pruning on tree architecture and functioning is complex to measure and predict.
- Functional-structural plant (FSP) models can be used to disentangle the instant and long-term effects of pruning on tree functioning and they can help designing effective pruning strategies in term of modality, intensity and timing.
- Detailed information on cocoa branching patterns in response to pruning are missing, but are required in order develop a FSP model of cocoa and to improve cocoa pruning effectiveness.

Aims: Understanding cocoa branching pattern in response to pruning and develop a FSP model of cocoa trees able to simulate effect of formation pruning on cocoa architecture and biomass accumulation.

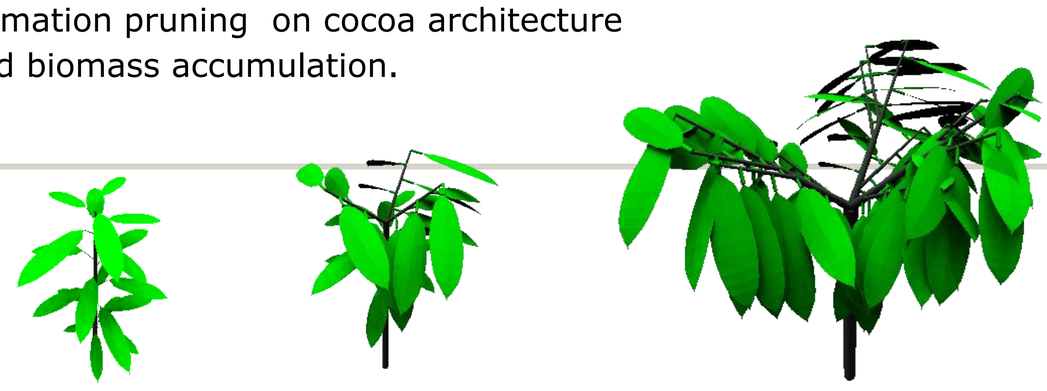

Figure 2. Examples of visual 3D outcome of FSP cocoa model.

Methods

Calibration experiment

- We applied five pruning treatments including a control to 2 years old trees in an experimental field in Côte d'Ivoire (Fig 1).
- Before pruning and after the first flush, number and position of lateral branches were measured.
- We estimated the probability of branch emergence as a function of position along a branch (rank) using generalized mixed effect models

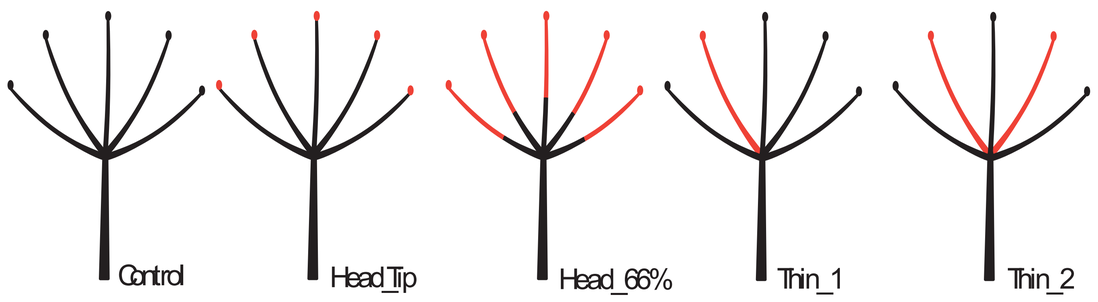

Figure 1. Schematic representation of pruning treatments. In red are sections removed by the treatments.

Model description

- Our FSP model simulates growth and development and 3D architecture of cocoa trees. Architectural and developmental characteristics specific to cocoa trees are included, such as the dimorphism of orthotropic and plagiotropic branches, jorquetting and flushing.
- Light interception is calculated at leaf level, driving leaf photosynthesis. Trees growth is an emergent property of source-sink driven allocation of assimilates.
- Virtual pruning modifies the probability of bud break, resulting in emergent branching patterns. Probability of bud break is calculated using a logistic function calibrated with data from the calibration experiment.

Results of calibration experiment

- Emergence of new branches during a flush cycle is concentrated in the section of the primary branch that had developed before the last flushing event.
- The pattern of branch emergence was modified by the different pruning treatments, but it also varied among plants and branches.
- Probability of branch emergence decreased with the number of secondary branches already present on a primary branch.

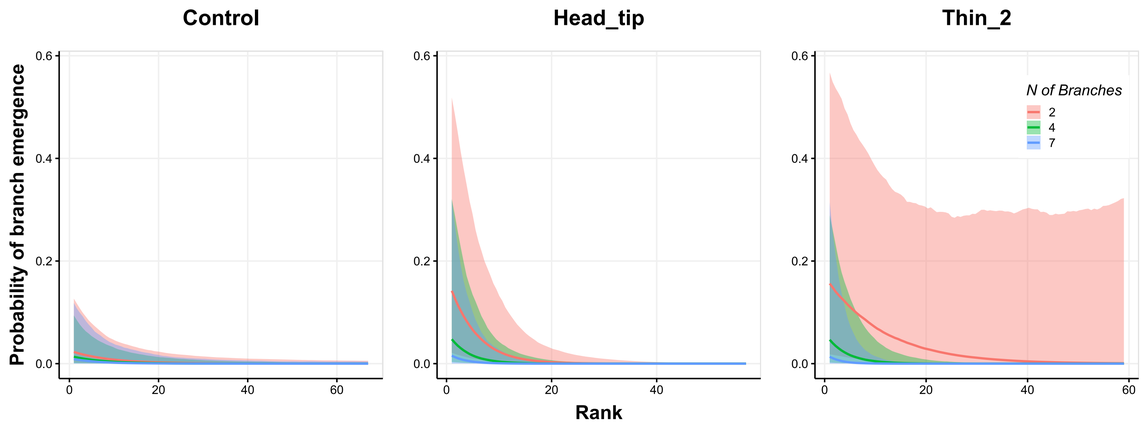

Figure 3. Probability of branch emergence as a function of rank and number of already present lateral branches for control treatment and two pruning treatments.

Upcoming work and outlook

- The model performance will be evaluated using data from a formation pruning experiment on cocoa trees in Côte d'Ivoire.
- The cocoa FSP model potentially serves as a tool to address relevant issues in cocoa production, such as optimal pruning practice and planting design.
- It could be used for screening promising trial options and for ideotyping plant structure for breeding purposes.
- The 3D visual output makes the model a potential communication tool for academic and non-academic audience

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