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Modelling the Guayule plant growth and development with a Functional Structural Plant Model

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Introduction

The Guayule (*Parthenium argentatum, Asteraceae*), is a branched shrub native to northern Mexico showing a growing interest in research and agriculture (Ray, 1993). However, few studies have been done on the structure or functioning of the species and the production itineraries in relation to natural rubber production are still to assess. This study aims to propose a first FSPM of the species using the GreenLab model, calibrated with data issued from two varieties in different environmental conditions. The objective is to understand the interaction between the development of Guayule and natural rubber production.

Materials and Methods

Experimental plots were conducted on two varieties (Fig. A), named CL1 (parent USDA 11591 triploid) and CLA1 (parent USDA AZ 101 tetraploid). The CL1 variety has small stem and leaf size compared to the CLA1 variety. These varieties were planted in the field under various environmental conditions related to density (9091 and 62500 plants/ha), and hydric pressure (100%, 66% and 33% of optimal supply).

The measurements carried out to count number of phytomers per module as well as the number of relay axes. We also clustered the total dry weight of leaves and stems per module in order to build the axis organic series (Buis and Barthou, 1984) and to estimate the content of natural rubber from a NIRS analysis (Taurines et al., 2019). The field measurements from the series constituted a target to calibrate the GreenLab model functional parameters such as the organ sink functions (Kang et al, 2018). We chose such a cohort model, since the structure (here the module rank) can be analysed in the biomass production without detailed explicit geometrical computations.

Results and Discussion

Experimental results. The Guayule shows a sympodial development composed of modules with a terminal inflorescence. Its architecture corresponds to the Leeuwenberg's model (F. Hallé *et al.* 1978) producing eight to nine modules per year. The number of internodes within the modules is almost stable regardless of variety and environmental conditions. The architecture of the two varieties CL1 and CLA1 is very similar, including the duration of the functioning of the organs (leaves and inflorescences). In the experiment, the biomass production per module (and thus per plant) was shown to be dependent on both density and water supply, according to the variety. Natural rubber content was found higher on young modules, and the water regime affected the natural rubber content of modules according to the variety (Fig. B).

Modelling results. We have modelled the number of internodes per module with a constant binomial law. The number of relay axis per module was modelled with a damped binomial law, simulating the branching rate decreases on young modules. These laws allowed simulating the plant structure (Fig. C). We then retrieved the organ sinks parameters, fitting the target file, and found significant differences in the leaf sink functions, stronger for the variety CLA1. As a result, the simulation of the functional model allowed the module diameters and the total plant height of the two varieties to be recovered correctly (Fig. D.). We still need to validate the relation between the internode growth and natural rubber production from new field analysis.

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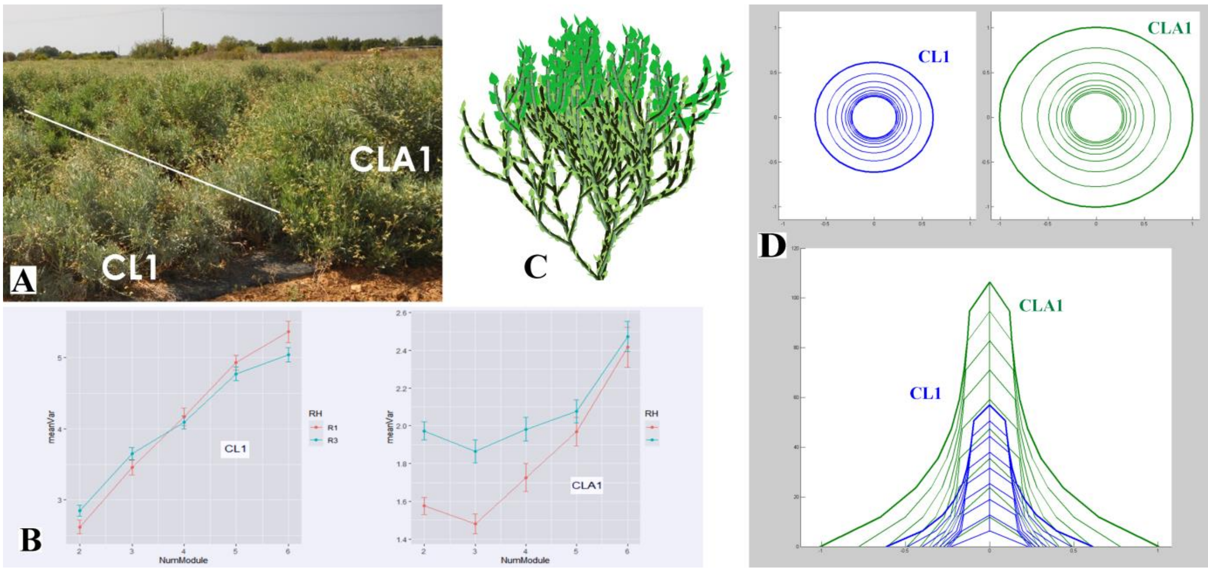

Figure: FSPM Guayule model. A: Field view with CL1 & CLA1 varieties. B: Measured values of the natural rubber content (%) in the optimal (R1) and restricted (R3) irrigation scenarios. C: Simulation of the CL1 structure model. D: Functional structural simulation of primary and secondary module growth on both varieties.

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