An FSPM approach for modeling fruit yield and quality in mango trees

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Research focus - Mango (Mangifera indica L.), the fifth most cultivated fruit in the world, is mainly produced in tropical and subtropical regions. Its cultivation raises a number of issues: (i) mango yield is irregular across years, (ii) phenological asynchronisms within and between trees maintain long periods with phenological stages susceptible to pests and diseases, and (iii) fruit quality and maturity are heterogeneous at harvest. To address these issues, we developed an integrative model synthesizing the knowledge acquired on the vegetative and reproductive development of mango tree architecture and fruit quality. Its objective was to simulate yield and quality of mango at the tree scale over successive growing cycles.

Methods - The proposed functional-structural plant model of the mango tree combined complementary architectural, phenological and ecophysiological knowledges and relied on two sub-models parameterized for the cultivar Cogshall in Réunion Island. The first sub-model simulated the development of mango tree architecture. The appearance of the different organs (growth units, inflorescences, fruits) was decomposed into elementary events describing the occurrence, the intensity and the timing of vegetative and reproductive development. These events are affected by structural and temporal architectural factors and the corresponding probabilities were estimated using generalized linear models, leading to development rules. Daily growth and development of growth units and inflorescences were modelled using empirical size distributions and thermal time. Fruit growth and quality development were simulated by a second sub-model. It took into account the effects of the environment and accounted for carbon- (i.e., leaf photosynthesis, mobilization/storage of reserves, respiration, demand for growth and carbon allocation) and water-related (i.e., water flows driven by stem and fruit water potentials and fruit transpiration) processes occurring at the branch level during fruit growth. The model was implemented using L-systems.

Results - A simulation of the model gave an integrative view of the dynamics of the population of growth units, inflorescences and fruits at the tree scale during a growing cycle. A detailed study of the growth units and inflorescences demography made it possible to assess the importance of the structural and temporal architectural factors on vegetative and reproductive development. The model made it also possible to investigate the variability of fruit quality within the tree.

Conclusions – This integrated model allowed us to explore the effects of different architectural factors on the architectural development of the tree, on yield, and on fruit quality. The next step will be to include in the model the effects of cultural practices, in particular pruning, on the mango tree development and yield.