Coupling the functional-structural plant models MAppleT and QualiTree to simulate carbon allocation and growth variability within Apple tree

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Plant growth highly depends on the carbon allocation which results from combined effects of environment, horticultural practices and management. QualiTree had demonstrated to be a useful model to simulate carbon allocation within the tree structure for peach trees submitted to contrasted cultivation practices (crop load) and soil water availability. The objective of this study was to adapt QualiTree to apple trees to simulate carbon economy and growth dynamics as well as variability within tree. Peach tree architecture is managed by standardized pruning practices whereas apple tree pruning is more tailored this leading to a greater variability of architecture. To take this variability into account, we used MAppleT to generate random tree architectures corresponding to the 'Fuji' cultivar. The architecture generated by MAppleT was saved into a Multiscale Tree Graph (MTG) and included information on all shoots and fruits location as well as their initial weights. This information was then used as input for QualiTree. Furthermore, based on the observed growth capacity of apple tree annual shoots, we modified QualiTree to take into account three different classes of shoots (long, medium and short) that are characterized by different growth rate and duration. The light interception sub-model, based on a turbid medium hypothesis, was also modified to allow the usage of user-defined ellipsoids to better represent the shape of apple trees. To calibrate the model, different parameter combinations of initial relative organ/shoot growth rate, maximum shoot biomass and duration of growth were tested to simulate adequately the variability of fruit and leafy shoot growth. The simulations were compared to previous 3-dimensional digitized measurements performed on 'Fuji' apple trees. Finally, the new version of QualiTree was used to simulate the impact of water stress, tree architecture and fruit load effect on organ growth dynamics and variability within tree structure. This modeling approach coupling MAppleT and QualiTree would help deeper understanding on complex interaction between growth, architecture and cultivation practices. To reach this objective, further works are needed to integrate into MAppleT retroaction loops between carbon allocation and plant architecture establishment.

Keywords: apple, functional structural plant model, carbon allocation, growth variability, architecture