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Integration of a mechanistic biochemical and biophysical leaf gas exchange model in L-PEACH

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L-PEACH is a functional structural model that simulates the growth of peach trees based on carbon partitioning between organs. Further development incorporated water transport, through transpiration and water potential, allowing studies of the effect of water stress on carbon partitioning (Da Silva *et al.* 2011). Our first approach to model leaf photosynthesis and transpiration with environmental sensitivity at an hourly time step, based on Kim and Lieth (2003), was not validated or computationally optimised. To overcome these issues we used the LEAFC3 model published by Nikolov *et al.* (1995). This model was computationally optimised and validated for forest trees and annual crops and it has been included in functional structural barley models. Even though LEAFC3 has been validated at the leaf level, this was done using an enclosed chamber, hence avoiding issues corresponding to whole plant estimations. Nikolov's model assumed that the leaf temperature was an input of the model or it was estimated from the bi-directional short and long-wave radiation absorbed by the leaf, which can be easily determined in an enclosed leaf chamber but is complex to determine in an open canopy. Instead, we employed an empirical function obtained from measurements of canopy temperature in peach trees growing in a well irrigated orchard (Glenn *et al.* 1989). This function connected the difference between leaf and air temperature to vapour pressure deficit, which can be estimated from air temperature and relative humidity. Hence, using this function is simpler and more computationally efficient than the energy balance previously used (Nikolov *et al.* 1995).

The leaf sub-model was developed as a stand-alone module that was integrated into L-PEACH as shown in Figure 1. The model was successfully used to simulate the effects of relative humidity on peach growth. This model integration is an important step for using functional-structural plant models in further studies to investigate long term effects of different environmental variables on canopy photosynthesis, transpiration, structure and yield characteristics, thus improving our understanding on the interactions of perennial plants with the environment.

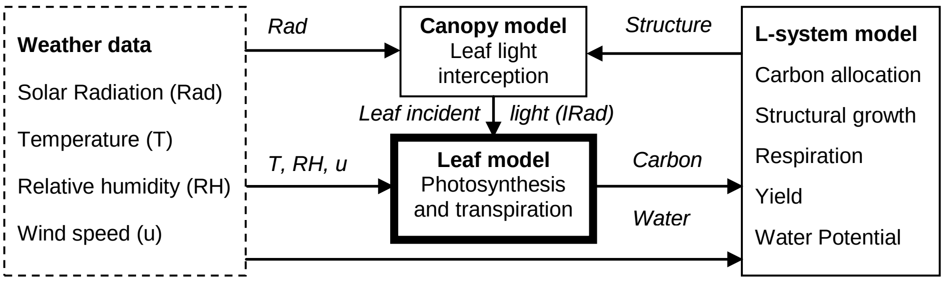

Fig. 1. Schematic representation of the integration of the mechanistic biochemical and biophysical leaf gas exchange model (leaf model) and the interactions with other sub-models in L-PEACH.

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