Relative contribution of foliage display and leaf functions to branch physiological capacities in two apple cultivars: a functional-structural modeling approach

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Introduction

The vegetative and reproductive growth of fruit trees depends on assimilate production which is controlled by tree canopy structure and leaf functions, both modulated by their interactions with the environment (Lakso 1994). Understanding more precisely how these factors influence the variation of growth and yield is a major issue for fruit growers. Functional-structural plant models (FSPMs) offer promising perspectives to understand these complex interactions at different spatial and temporal scales (Godin and Sinoquet 2005). In this context, the aim of the present study was to unravel in apple the relative contribution of foliage display and leaf functions (leaf stomatal and photosynthetic properties) on light interception, transpiration and photosynthetic capacities of branching systems.

Material and methods

Two apple (*Malus* x *domestica* Borkh.) cultivars with contrasted architectures, 'Fuji' and 'Braeburn' were studied at the INRA experimental station of Melgueil (near Montpellier, France). Three eight-year-old trees per cultivar, grafted on M9 rootstock, were digitized to obtain 3-D representations of foliage geometry. Branch light interception was estimated by STAR (Silhouette to Total leaf Area Ratio) values on the tree mock-ups. Branch transpiration was measured in field by sap flux and net photosynthetic rate by branch bags. A set of parameters previously established in both cultivars (Massonnet et al, submitted) was used to run RATP model (Radiation Absorption, Transpiration and Photosynthesis, Sinoquet et al., 2001). The RATP outputs were evaluated by comparison against measurements. The model was then used to evaluate the impact of virtual scenarii switching foliage display and/or leaf functions on light interception, transpiration and photosynthetic capacities at branch scale in both cultivars.

Results and discussion

'Fuji' branches presented lower leaf area density (LAD) values than Braeburn. Consequently, this resulted in higher STAR values, transpiration and photosynthetic rates in 'Fuji' than in 'Braeburn' branches. The analysis of the virtual scenarii revealed that the variations in foliage display and leaf functions had additive effects on the reduced transpiration and photosynthetic rates of 'Braeburn' branches compared to 'Fuji'. Leaf display and leaf functions had equivalent impacts on branch transpiration rates while the former had a predominant impact on branch photosynthetic rates. This can be interpreted as a consequence of the difference in leaf stomatal conductance between the cultivars whereas their leaf photosynthetic capacity was similar.

Conclusion

This study demonstrated the relevance of FSPM to disentangle physiological differences between cultivars through an *in silico* approach. We showed here the large impact of foliage display on the branching system functions. This study could be further investigated through additional studies of the complex interactions between plant structure, leaf physiology and environment at different time scales, making use of recent dynamic simulations of apple tree development (Smith et al., submitted).

References

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