Highlight of the “EJA paper of the month” (#2 - October 2011)

2D approximation of realistic 3D vineyard row canopy representation for light interception and light intensity distribution on leaves.

by Lopez-Lozano, F. Baret, I.García de CortázarAtauri, E. Lebon and B. Tisseyre, 2011. European Journal of Agronomy 35(3): 171-183.

Most of the studies on light micro-climate in vertically-trained vineyard are based on a 2D approach in which vineyards are represented by parallelepiped rows assuming that leaves are randomly distributed within the row volume. However, leaves are aggregated around branches in actual vineyard canopies, which invalidates the assumption on random distribution of leaves. This may thus induce possible errors on light microclimate using such a 2D representation. Moreover, the shape of vertically trained vineyards is sometimes complex and can hardly be approximated by a parallelepiped pattern due to relatively frequent lateral branching and differences in the inclination of main shoots. Departure from the simple 2D representation depends on several factors including the trellis system that controls the inclination and trajectory of main shoots and the plant vigor determining the branching intensity that is also modulated by the pruning practices which reduce the potential branching and modify the original shape of the canopy

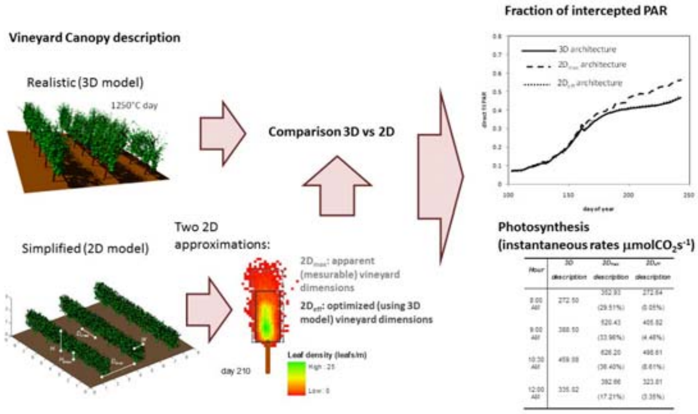
The objective of this study is to evaluate the performances of current 2D approaches for the simulation of canopy light regime through fIPAR(fraction of intercepted photosynthetically active radiation), fILA (fraction of illuminated leaf area) and LIDIL (distribution of light intensity on illuminated leaves) as well as their consequences on the estimation of canopy photosynthetic rates. Performances are evaluated against a dynamic 3D model of vineyard architecture based on the work of Louarn (2005) and Louarn et al., (2008a,b) that is considered as the reference. This model incorporates a detailed description of leaves spatial arrangement, coupled to a water balance model in order to simulate the different levels of leaf area development depending on water availability. In a 2D approximation to an actual vineyard canopy is critical how the row dimensions (height and width) are determined. In the present study two different strategies were selected:

- The maximum bounding box ($2D_{max}$). This strategy aims at defining row dimensions of vineyards easy to measure in the field. All the leaves represented in the 3D model are first projected onto a plane perpendicular to the row. Then, the mode of maximum height (width) of pixels occupied by leaves for each column (row) on the projected images is used to define W(H).

- The effective bounding box ($2D_{eff}$).This second strategy aims at providing a 2D representation that would provide the same fIPAR values as those of the detailed 3D representation. In this case, W and Hare adjusted using the Simplex algorithm (Matlab software, MathworksInc, USA) to minimize the difference in the daily fIPARtime course between the 2D and 3D representations.

The results showed consistent simulations between $2D_{eff}$ and the reference 3D model for the three light regime variables investigated. Conversely, discrepancies were observed between $2D_{max}$ and the reference 3D model both for fIPAR and fILA: The $2D_{max}$ model overestimates the actual fIPAR (up to 22%) and fILA (up to 50% in some cases) .These differences increased with LAI values, and are associated to an overestimation of row height. Conversely, LIDIL simulated for the $2D_{max}$were consistent with those obtained with both 3D and $2D_{eff}$ models. The canopy level photosynthesis rates, computed using the leaf model of Schultz (2003), confirmed the adequacy of a 2D effective row structure approximation.The $2D_{max}$ approximation leads to systematic overestimation of photosynthesis rates that can reach up to 36%.

Although an effective 2D approximation seems very pertinent for light regime simulations in the PAR domain where multiple scattering is marginal, it was difficult to relate the effective dimensions to other canopy architecture features easy to measure in the field, row height being the most sensitive characteristic.



More information

DOI: http://dx.doi.org/10.1016/j.eja.2011.06.005

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