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Evaluation of a photon tracing model and virtual plants to simulate light distribution within a canopy in a growth chamber

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Highlights: Radiance distribution in a growth chamber is anisotropic. Our objective is to evaluate the accuracy of light simulations in a rose canopy grown in a growth chamber using virtual plants and a photon tracing model dedicated to growth chambers. The question of the scale at which the system reproduces the observed variability is specifically addressed.

Keywords: photon tracing model, growth chamber, light phylloclimate, plant architecture

Growth chambers are frequently used to study plant physiology. Yet, in growth chambers, in addition to light variations due to plant architecture there is a strong anisotropic distribution of radiance due to the characteristics of the chamber itself. A photon tracing model was developed to simulate light distribution in growth chambers (SEC2, Chelle et al. 2007). Our objective is to evaluate SEC2 ability to simulate accurately light distribution in a canopy using virtual plants.

In a first step the virtual representation of the growth chamber included the geometry and the optical properties of the surfaces, as well as a representation of the light sources. This virtual growth chamber was used to simulate the 3D radiative field using the SEC2 model. In absence of plants, the simulation predicted well the light distribution in a 40 cm thick horizontal layer corresponding to usual canopy occupation (RMSEP=6.2%). A second step consisted in the evaluation of the model for light simulated within five canopies of rose bushes differing in individual plants architecture. Spectral irradiance was measured with different sensor orientations and at different locations within the canopy. Some locations were very close to each other to study the micro-local variability, whereas other locations were chosen to assess light vertical and horizontal (border effect) penetration in the canopy. Measurements show that the light variability was high, *e.g.*: the differences in photon flux density in the red waveband was up to 159% at the same position between two canopies, and up to 91% at 1 cm of distance within a canopy. The plants constituting the canopies were digitized (Polhemus Fastrack, Colchester, USA) and the reconstitution of the virtual canopies in the virtual growth chamber are in progress. The comparison of the simulations with the measurements will assess the ability of the whole system (photon tracing model, in silico reconstruction of growth chamber and plants) to simulate light distribution in a canopy in a growth chamber for PAR, red:far red ratio and blue light. We will specifically address the question of the scale at which light variability is correctly accounted for: are the general tendencies as vertical/horizontal light penetration simulated? the micro-local variations?

In the system evaluated here all interactions among light sources, materials and plants were modelled, as in Buck-Sorlin et al. (2011) for glasshouses, which is an alternative to Chenu et al. (2008) who characterized the radiative system by measurements. These results will assess the ability of the system to be further used to investigate plant response to phylloclimate.

LITERATURE CITED

Buck-Sorlin G, De Visser PHB, Henke M, Sarlikioti V, Van der Heijden GWM., Marcelis LFM, Vos J, 2011. Towards a functional-structural plant model of cut-rose: simulation of light environment, light absorption, photosynthesis and interference with the plant structure. *Annals of Botany* **108***:* 1121-1134.

Chelle M, Renaud C, Delepoulle S and Combes D, 2007. Modeling light phylloclimate within growth chambers, In: Prusinkiewicz P, Hanan J, Lane B eds. *Functional-Structural Plant Models. 5th International Workshop.* Napier (NZ), 571-574.

Chenu K, Rey H, Dauzat J, Lydie G, Lecoeur J, 2008. Estimation of light interception in research environments: a joint approach using directional light sensors and 3D virtual plants applied to sunflower (*Helianthus annuus*) and *Arabidopsis thaliana* in natural and artificial conditions. *Functional Plant Biology* **35** : 850-866.