Comparison of two different light models using a virtual tomato crop

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Static 3D virtual plants in connection with radiation models have proven to be valuable tools to investigate the effect of single-plant architecture as well as crop structure (row and plant spacing) on light interception and canopy photosynthesis. Approaches to compute light distribution and interception in virtual plant stands include path tracing and nested radiosity. In path tracing the direction of a ray from the light source to an intercepting object, as well as its further fate (reflection, transmission, absorption), are chosen stochastically. Nested radiosity computes the irradiance over a polygon as a sum of two components, polygons nearby and farther away. We compared two different radiation models implementing these two approaches in terms of suitability and computation time efficiency. Measurements of plant architecture were conducted on five tomato plants grown on slabs in hydroponic culture. Light interception was measured at 8 different spots in the greenhouse at 25 cm interval from top to the bottom. Virtual plants were reconstructed with parametric L-systems in cpfg (in L-Studio) and XL (in GroIMP). The static cpfg tomato model was coupled with the Caribu light model, and the nested radiosity (NR) option with "infinity" was used. The static XL model was linked to the GroIMP radiation model (a Monte-Carlo pathtracer (MCPT), with one billion rays, ten reflections per ray). Both models used as light source 72 directional lights that mimicked diffuse light conditions. Stacks of virtual light sensors were placed horizontally in the scene. Both NR and MCPT gave an accurate correlation between measured and simulated values (Fig. 1). Computational time varied between 6 and 12 hours (NR) and 74 minutes (MCPT). The simulated light extinction pattern was the same for both approaches. However, in NR we observed lower light intensities in the lower canopy. Also, light intensity constantly decreased with increasing canopy depth whereas a constant or only slightly decreasing light level was observed in the lower canopy in MCPT. In MCPT an infinite canopy similar to Caribu could be mimicked by using more buffer rows. Future work will be done on exploring the effect of the size of the bounding box in Caribu and on introducing an infinite canopy to the GroIMP radiation model.

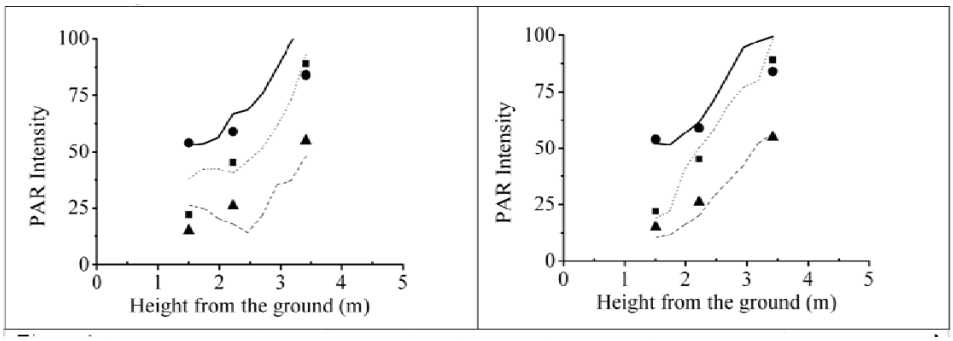

Figure 1: Vertical PAR gradient simulated using the MC raytracer of GroIMP (left) and the nested radiosity model of cpfg (right). Lines: simulated data; symbols: measured values.
…■: perpendicular to the crop, –●: in path, parallel to the crop, --▲: parallel between the rows.