



Optimizing illumination in the greenhouse using a 3D model of tomato and a ray tracer.

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Résumé en anglais

Reduction of energy use for assimilation lighting is one of the most urgent goals of current greenhouse horticulture in the Netherlands. In recent years numerous lighting systems have been tested in greenhouses, yet their efficiency has been very difficult to measure in practice. This simulation study evaluated a number of lighting strategies using a 3D light model for natural and artificial light in combination with a 3D model of tomato. The modeling platform GroIMP was used for the simulation study. The crop was represented by 3D virtual plants of tomato with fixed architecture. Detailed data on greenhouse architecture and lamp emission patterns of different light sources were incorporated in the model. A number of illumination strategies were modeled with the calibrated model. Results were compared to the standard configuration. Moreover, adaptation of leaf angles was incorporated for testing their effect on light use efficiency (LUE). A Farquhar photosynthesis model was used to translate the absorbed light for each leaf into a produced amount of carbohydrates. The carbohydrates produced by the crop per unit emitted light from sun or high pressure sodium lamps was the highest for horizontal leaf angles or slightly downward pointing leaves, and was less for more upward leaf orientations. The simulated leaf angles did not affect light absorption from inter-lighting LED modules, but the scenario with LEDs shining slightly upward (20°) increased light absorption and LUE relative to default horizontal beaming LEDs. Furthermore, the model showed that leaf orientation more perpendicular to the string of LEDs increased LED light interception. The combination of a ray tracer and a 3D crop model could compute optimal lighting of leaves by quantification of light fluxes and illustration by rendered lighting patterns. Results indicate that illumination efficiency increases when the lamp light is directed at most to leaves that have a high photosynthetic potential.

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