What is the most prominent factor limiting photosynthesis in different layers of a greenhouse cucumber canopy?

Titre	What is the most prominent factor limiting photosynthesis in different layers of a greenhouse cucumber canopy?
Type de publication	Article de revue
Auteur	Chen, Tsu-Wei [1], Henke, Michael [2], de Visser, Pieter H. B. [3], Buck-Sorlin, Gerhard [4], Wiechers, Dirk [5], Kahlen, Katrin [6], Stützel, Hartmut [7]
Pays	Royaume-Uni
Editeur	Oxford University Press (OUP)
Type	Article scientifique dans une revue à comité de lecture
Année	2014
Langue	Anglais
Date	Jan-09-2014
Numéro	4
Pagination	677-688
Volume	114
Titre de la revue	Annals of Botany
ISSN	0305-7364
Mots-clés	canopy photosynthesis [8], cucumber [9], Cucumis sativus [10], diffuse light [11], functional–structural plant model [12], FvCB model [13], GPU [14], graphics processing unit [15], GroIMP [16], photosynthetic limitations [17], quantitative limitation analysis [18]

Résumé en anglais	Background and Aims Maximizing photosynthesis at the canopy level is important for enhancing crop yield, and this requires insights into the limiting factors of photosynthesis. Using greenhouse cucumber (Cucumis sativus) as an example, this study provides a novel approach to quantify different components of photosynthetic limitations at the leaf level and to upscale these limitations to different canopy layers and the whole plant. Methods A static virtual three-dimensional canopy structure was constructed using digitized plant data in GroIMP. Light interception of the leaves was simulated by a ray-tracer and used to compute leaf photosynthesis. Different components of photosynthetic limitations, namely stomatal (SL), mesophyll (ML), biochemical (BL) and light (LL) limitations, were calculated by a quantitative limitation analysis of photosynthesis under different light regimes. Key Results In the virtual cucumber canopy, BL and LL were the most prominent factors limiting whole-plant photosynthesis. Diffusional limitations (SL + ML) contributed <15 % to total limitation. Photosynthesis in the lower canopy was more limited by the biochemical capacity, and the upper canopy was more sensitive to light than other canopy parts. Although leaves in the upper canopy received more light, their photosynthesis was more light restricted than in the leaves of the lower canopy, especially when the light condition above the canopy was poor. An increase in whole-plant photosynthesis under diffuse light did not result from an improvement of light use efficiency but from an increase in light interception. Diffuse light increased the photosynthesis of leaves that were directly shaded by other leaves in the canopy by up to 55 %. Conclusions Based on the results, maintaining biochemical capacity of the middle–lower canopy and increasing the leaf area of the upper canopy would be promising strategies to improve canopy photosynthesis in a high-wire cucumber cropping system. Further analyses using the approach described in this study can be expected to provide insights into the influences of horticultural practices on canopy photosynthesis and the design of optimal crop canopies.
URL de la notice	http://okina.univ-angers.fr/publications/ua8872 [19]
DOI	10.1093/aob/mcu100 [20]
Lien vers le document	http://dx.doi.org/10.1093/aob/mcu100 [20]
Titre abrégé	Annals of Botany

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