Full control of greenhouse crop production based on physiological knowledge

Leo F.M. Marcelis*

Professor of Horticulture, Wageningen University, Chair group Horticulture and Product Physiology, Wageningen, The Netherlands

*Corresponding author: Leo.marcelis@wur.nl

Abstract

The growing world population requires strong increases in vegetable production. Simultaneously, consumers demand that vegetables as well as ornamentals are of high quality and that they are produced sustainably. To meet all the requirements we need to have a high level of control over the production process. Production in greenhouses or in buildings (often indicated by terms as vertical farming, or city and urban farming) allows a precise control over the production process. Yield per m^2 of several crops grown in greenhouses has doubled over the last 25 years. For greenhouse grown tomatoes it was estimated that about 25% of the yield improvement was due to breeding and 75% due to improved growth conditions and cultivation techniques. Exploitation of the physiological potential of plants for optimizing production and product quality requires the use of explanatory simulation models. New developments in plant modelling can be found in functional-structural models (FSPM) and systems biology models. For instance, calculations by an FSPM for tomato plants indicated that crop photosynthesis could be improved by about 10% when genotypes with a more open canopy structure would be developed. Models should be well embedded in experimental research. Furthermore, when models are combined with plant sensors they are ideal tools for growers to monitor and control the performance of their crops. Recently many innovations in greenhouse horticulture are related to the smart use of both solar and artificial light. Greenhouse covers that scatter direct solar radiation without influencing the transmissivity improved crop production in several crops up to 10%. In tomato this increase was due to the improved vertical and horizontal light distribution, a larger photosynthetic capacity of the lower leaves and a larger leaf area index. In heavily shaded potted plants like anthurium and bromeliads, substantially less shading is necessary under diffuse light and well controlled growth conditions, which enhances crop photosynthesis. In this way yield improvements of up to 50% were observed. Many growers use supplementary light to improve production and quality in the winter season. High pressure sodium (HPS) lamps are still the most common lamps use. However, LEDs are now being introduced. Modern LEDs may convert electricity into light 25% more efficiently than high pressure sodium lamps. Even more important are the possibilities to influence physiological and morphological processes by manipulating the positioning, timing and spectrum of the lamps. Besides stimulating growth and development, light can also be used to improve quality attributes of horticultural products, including vitamin C content.