Dynamic vs constant light: following the nature

G. Samuolienė*, A. Brazaitytė, V. Vaštakaitė-Kairienė, J. Miliauskienė, P. Duchovskis & A. Viršilė

Institute of Horticulture, Lithuanian Research Centre for agriculture and Forestry, Kauno str. 30, 54333, Babtai, Lithuania
*Corresponding author: giedre.samuoliene@lammc.lt

Keywords: light-emitting diodes, metabolism, morphogenesis, photoresponse, vegetables

In closed environment agriculture constant artificial lighting is usually applied. Thus, there is no shift between increase/decrease of photon flux density (PFD), which allows photosynthesis system to adapt to the turnover of day and night. Based on the idea, that parabolic lighting is more efficient for photosynthesis and antioxidant systems. Thus, the efficacy of constant and parabolic lighting profiles was evaluated. Applying the light-emitting diodes technological possibilities, based on natural lighting principles and physiological plant response, the lighting models were created for various growth strategy vegetables (lettuce, radish and tomatoes) seeking for their physiological homeostasis, high nutritional value and optimal productivity.
Naturally during all seasons in the morning spectrum blue (B), during day – red(R) component was dominating, in the evening increased B input was observed. The total PFD mostly fluctuated in summer, while change in spectral composition was more expressed in autumn. Based on the plant type and daily light integral, the model of dynamic lighting calculator was created. The parabolic B increased transpiration and secondary metabolism processes, while parabolic R resulted intensive photosynthesis and primary metabolism processes. The most favourable lighting conditions for lettuce seedlings was BR or BRG. Supplemental UV-A negatively affected the photoresponse of red leaf lettuce, the antioxidant response was lower under poorer lighting. For good quality tomato seedlings, the ratio of B:R is important, for biomass accumulation (higher pigment, antioxidant compounds, mineral elements (especially K, Mg)) small amount of green light is beneficial; for flowering and fruiting the increased B or supplemental UV-A was significant. The physiological response of radish, lettuce and tomato depended on PPFD applied during morphogenesis stage. More appropriate PPFD for radish was 150, and for lettuce 250 μmol $m^{-2}s^{-1}$. The parabolic PPFD profile, concentrated in shorter (12-16h) photoperiod, stimulated photosynthesis and didn't cause the photostress or photoinhibition. Red leaf lettuce distinguishes in higher antioxidant properties and were less sensitive to lighting. The most different response of physiological indices to BR parabolic changes was expressed in Grand rapids and Vizir lettuces. While no significant changes on physiological response of Affición and Lobjoits green cos lettuces was obtained. RBG positively affected the formation of leaf area and biomass; higher fructose, glucose and sucrose levels, and antioxidant properties were determined compared with RB or RG. In contrast to protein involved in chlorophyll synthesis, the expression of β carbon anhydrase 2, protein involved in C3 metabolic pathway, was increased under RB and decreased under RG. Thus, the deficiency of B was significant for specific proteins expression. Application of far-red light during day increased accumulation of soluble sugars in tomato fruits, while the shift into night increased the concentration of ABA and JA, and decreased the content of flavonols, Zn and S in leaves. The effect of light and other environmental factors on lettuce physiological response: N>PPFD>Spectrum>T°C>Lighting profile. The effects of parabolic lighting were significant only in suboptimal temperature conditions, while, in intensive N nutrition, the parabolic lighting had no significant effect. Developing dynamic lighting strategies for effective photosynthesis and high productivity is important to take into account the optimal lighting parameters for plant genotype and possible effect of other environmental factors.