Integrated Morphological, Biochemical, and Transcriptomic Responses of Greenhouse Crops to Spectral Modification Using Light-Converting Films

Dauren Kabdrakimovich Mukhanov
PhD Student, Department of Chemistry and Chemical Technology, Al-Farabi Kazakh National University, Almaty, Kazakhstan

Mutushev Alibek Zhumabekovich
PhD, Principal Research Scientist, Scientific Center for New Technologies, AlAkSan
Assistant Professor, Department of Chemistry, Chemical Technology and Ecology, Almaty Technological University, Almaty, Kazakhstan

Nuraly Assiya Mambetkyzy
PhD, Principal Research Scientist, Scientific Center for New Technologies, Center for Advanced Science and Technology,
Assistant Professor, Department of Chemistry, Chemical Technology and Ecology, Almaty Technological University, Almaty, Kazakhstan

Sanat Aida Sayatkyzy
Master, Senior-Lecturer, Department of Chemistry, Chemical Technology and Ecology, Almaty Technological University, Almaty, Kazakhstan

Abstract

Light quantity, encompassing both intensity and photoperiod, and quality, referring to spectral composition, play crucial role in influencing plant growth and physiological processes. These light parameters interact with other environmental conditions and cultivation practices to shape plant behavior. Beyond serving as the primary energy source for photosynthesis, light also provides specific signaling cues that govern plant development, morphology, and metabolism through the complex process of photomorphogenesis, which is controlled by different light wavelengths. Even at minimal intensities, plants can perceive light through five distinct classes of photoreceptors, each with well-defined biochemical characteristics and physiological functions. In recent years, understanding of plant photomorphogenesis has advanced significantly, largely due to the widespread use of light-emitting diodes (LEDs). LEDs offer several advantages over traditional lighting systems, such as the ability to customize light spectra and adjust light intensity according to the specific needs of various crops and developmental stages. This growing body of knowledge holds great potential for application in greenhouse horticulture, allowing for the optimization of production timing, crop yield, and quality. This article presents different spectral components of artificial lighting influence plant growth and photomorphogenesis in vegetable and ornamental species. It also summarizes current research on the use LEDs in greenhouse cultivation, focusing, when possible, on the effects of individual light wavebands, as most existing studies primarily address combined spectral effects.

Keywords

Light spectrum, photoreceptors, plant, photomorphogenesis, LED.

Funding

This research has been/was/is funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP26195823).