

14HD6301, Suthisak SAENGTHARATIP

Prospect of LED light sources to enhance lettuce quality and productivity in plant factory.

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Graduate School of Horticulture. Chiba University.

Main advisor: Professor Michiko Takagaki, Ph.D. 100 pages.

Abstract

An artificial light is a primary issue for leafy vegetable cultivation in a closed plant production system. Several light sources have been established expecting for a new business trend. Among them, light-emitting diode (LED) as a major cultivating light is of interest. This dissertation has determined light spectra and characteristics in order to verify plant growth and quality of 3 lettuce cultivars. Initially, a mixed spectra types is established and represented a white LED type which emits photosynthetically active radiation (PAR) region as portrays to the sun spectrum. One white LED type, as a major downward light source, significantly exhibits different growth production of a lettuce cultivar, frill lettuce. Secondly, a green region of PAR has transmittance capability to be reflected and transmitted in a deeper leaf layer. Under high light intensity irradiation ($400 \mu\text{mol m}^{-2} \text{s}^{-1}$), ascorbic acid and chlorophyll is increased inside a round-shape lettuce type canopy, crisp head lettuce. Thirdly, an issue of high plant density production in the closed system is a senescent leaf. This phenomenon occurs because of chlorophyll degradation ensued from light inadequacy at bottom plant canopy. Upward lighting is a supplementary lighting technique to alleviate the leaf shading condition. Supplementary lighting of red and blue LED type are respectively the most effective, due to photosynthetic pigments light absorption. The technique is not only improving plant production, but also decreasing waste from the senescent leaf in romaine lettuce. Considering LED performance, the difference has been estimated with regard to confirm that using LED, as the plant production light source, is worthwhile for the system. Two-case study from this dissertation are applied to analyze economic feasibility under the market conditions prevailing in Tokyo, Japan. The first case, various white LED types, illustrates that the white LED types can be used to cultivate plant and obtained profitability. Whilst, the second case, supplementary light, is proven that profitability can be procured even more light sources are added. As a consequence, LED has latent potential to cultivate high quality and quantity lettuces. This light source is and will be bright future as the artificial light source in the closed plant production system with viable economics.