Investigation of LED light effects on plant growth in improved protected horticulture system

Nanjing Jiang[1], Steven Grundy[1] , Zhonghua Bian[2] and Chungui Lu[2,*]

1. School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, UK
2. School of Animal, Rural and Environmental Sciences, Nottingham Trent University, Brackenhurst Campus, Nottinghamshire, NG25 0QF, UK

*Corresponding author: Chungui Lu, Chungui.lu@ntu.ac.uk

In controlled environment agriculture, energy is the predominant factor in production costs. Lighting is the one major consumers of energy. Commercial crop production in greenhouses can be enhanced by supplemental lighting which provides low moderate intensity light levels to increase photosynthesis and plant growth. Traditionally, horticultural lights were high-intensity discharge lamps such as high-pressure sodium (HPS), metal-halide (MH), and mercury (HPMV). The disadvantages of these lamps are high-energy costs, heat generation and suboptimal spectrum for photosynthesis.

LED (Light emitting-diode) lamps are a promising technology that has tremendous potential to improve irradiance efficiency and to replace traditionally used horticultural lighting (Kozai et al., 2015). LED provides precise light spectrum and close illumination. Their small size, durability, long lifetime, and cool emitting temperature are more suitable for plant-based uses than many other light sources. Although equipment costs are still high, as is the case with most new technologies, growers are very keen to use LED lamps to substantially decrease their energy use and reduced carbon emissions. Photosynthesis of horticultural crops use mainly the wavelength of 610mm ~ 720nm red light, whose energy absorption equals approximately 55% of the total physiological radiation. That is followed by the wavelength of 400 ~ 510nm of blue-purple light, which accounts for approximately 8% of the total usage. Plants respond to spectral quality (i.e. colour) by altering their morphology (eg. Leaf area and stem length). This creates canopies that permit the plant to intercept light at high efficiency and drive photosynthesis to produce adequate yield. Current research on the effects of LED light has mainly focused on plant morphology, Less is known about the effect of LED light on the response of the photosynthetic system and changes in crop quality.

This project aims to investigate energy use efficiency and photosynthesis with the evaluation and improvement of protected horticulture system. At the initial phase the effects of different supplemental light including LED light on plant growth and photosynthesis in lettuce have been studied, the higher luminous efficiency and positive impact for plant's growth showed the great potential of LED facilities compared with other artificial light and indicated that it is the most appropriate light resource at this stage. Claims of 50% energy savings for similar biomass yields are now obtained in the study. Further, extending the species of crops for LED faming system have been used for potential maximum efficiency during plant growth and development (Lu et al., 2015). Furthermore, research has been performed to test quality of crops (flavour, nutritional value etc) from LED lamps in several specific wavelengths, notably far-red, red, blue, and green compared with HPS lamps at both enhanced crop quality and reduced energy cost for lettuce grown in a hydroponics setup. The results showed that Pre-harvest continuous LED light exposure can effectively reduce nitrate accumulation and increase phytochemical concentrations in lettuce plants, and the reduction in nitrate content is dependent on the spectral composition and continuous light duration. Lettuce plants grown under the continuous combined red, green and blue LED light (RGB) with a PPFD at 200 μ mol m-2 s-1 (RGB-CL) and RB-CL treatments exhibited a remarkable decrease of nitrate contents at 24 h compared to other LED light treatments. In addition, red and blue light (R:B=4:1) was more effective in facilitating lettuce plant growth than W LED light at the same PPFD (Bian et ac., 2016). Moreover, continuous LED light at 24 h significantly enhanced the DPPH free-radical scavenging activity and increase phenolic compound concentrations. In addition, molecular markers or genes associated with photosynthesis and plant growth under LED lighting by using high-throughput RNA Seq technology have been identified.

References

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