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The Impact of Supplemental LED Light on Night-time on the Growth, Inflorescence Weight, and Cannabidiol Content of Hemp

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A B S T R A C T

In recent years, the use of Light Emitting Diodes (LEDs) in the horticulture sector has gained popularity. LEDs can be utilized as supplemental illumination in greenhouse production systems or as the primary light source in indoor farming. In the current study, the impact of nighttime supplemental LED was compared with the use of natural light. The study revealed that the nighttime supplemental LED light for 8 hours increased the average daily light integral (DLI) by 10.72%. Hemp plants grow to a height of 70.80±11.12 cm when placed under natural light, compared to 83.60±17.05 cm under additional LED lighting at night. Hemp plants with LED light had an average of 16.20±1.79 branches, whereas those with natural light had an average of 13.40±4.45. The average weight of dry inflorescences collected under LED light was 29.40±11.84 g, whereas those picked under natural light were 29.00±9.77 g. The average cannabidiol (CBD) concentration was 10.31±0.33% when nighttime supplemental LED light was used, compared to 8.53±0.12% for natural light. The group that received nighttime supplemental LED light increased their CBD contents by 20.87%. This study has verified that nighttime supplemental LED lighting system can accelerate the secondary metabolism rate of C. sativa when compared with those plants cultivated under normal solar irradiance.

Keywords: Night-time supplemental LED, Hemp, Cannabidiol, Outdoor farming

1. Introduction

Cannabis usage has been extensively prohibited for over a century due to its potential for psychoactivity. Over the last decade, proof of its medical qualities has led to a relaxation of regulation in several nations throughout the world. As a result, research into the genetics and development of cannabis, as well as cannabis-derived products, is gaining momentum(Schilling et al., 2020). As a versatile crop, *C. sativa* has several applications including biofuel, textiles, construction materials, and paper (Schilling et al., 2020). Hemp can be difficult to farm in tropical and subtropical locations because of high temperatures, humidity, and the abundance of disease and pests. However, the relatively short daylengths observed in tropical and subtropical regions pose the most significant impediment to the effective production of hemp at lower latitudes (Moher et al., 2021; Schilling et al., 2020). Hemp is classified as an annual, dioecious, short-day plant that originated in temperate Asia. Most hemp types are photoperiodic, therefore blooming is determined by day duration or photoperiod (Moher et al., 2021).

Light promotes plant growth and development, therefore controlling it is becoming a popular environmentally friendly strategy for managing horticulture crops. Light-emitting diodes (LEDs) are rapidly being utilized in greenhouses, vertical farming, and growing cabinets, both with and without natural light (Demotes-Mainard et al., 2016). LEDs have relatively narrow-band spectra that do not mimic natural daylight, which is continuous in the Photosynthetic Active Radiation (PAR) area (400–700 nm). Furthermore, LEDs used in current horticulture emit little to no light in the far-red (FR) range (710-850 nm), resulting in red (R) to far-red (FR) ratios greater than those of natural daylight. The effects of extra FR or a less energy-intensive end-of-day far-red (EOD-FR) therapy on the shape and production of fruit-bearing crops cultivated under horticulture LEDs remain to be explored. Such research requires evaluating the effect of supplementing FR-enriched LEDs with natural sunshine (Kalaitzoglou et al., 2019).

In the past two decades, development of LEDs as an alternative light source has enabled not only researchers but also farmers to control spectral qualities. Most studies to date have integrated supplemental LED lighting technologies into greenhouses where no supplemental lighting was previously present or as additional lighting sources in greenhouses where top artificial lights (e.g., high-pressure sodium lights, high-pressure sodium lamps (HPS), lamps) were already installed and operational (Zakurin et al., 2020).

The aim of the study was to evaluate the efficiency of using nighttime supplemental LED light for *C. sativa* growing, yielding, and its influence on the CBD content in the cultivation of *C. sativa* using two different types of lighting.

2. Materials and Methods

2.1 Experimental Sites and Environmental Conditions

The study was conducted in an outdoor plantation at the community enterprise of pathanapiboon in Chiang Mai, Thailand from May to August 2023. The study was conducted on *C. sativa* Auto-blue chemovars. Seedlings of the *C. sativa* were produced on trays for 3-4 days, and then transferred to pot with dimensions 6.0 × 2.6 × 3.2 cm. The cultivation media was composed of coconut coir 50%, perlite 10%, vermiculite 10%, and specific media 30%. Twenty-one-day-old seedlings were used in the study. The experiment was performed in the outdoor. The experimental design was a completely randomized design (CRD) with two treatments of (1) natural light and (2) nighttime supplemental LED for 8 hours. The pots were arranged at a distance of 80 cm × 80 cm between and within rows (Fig. 1). The distance between the two groups is 2 meters. A total number of 16 pots were used for the experiment.

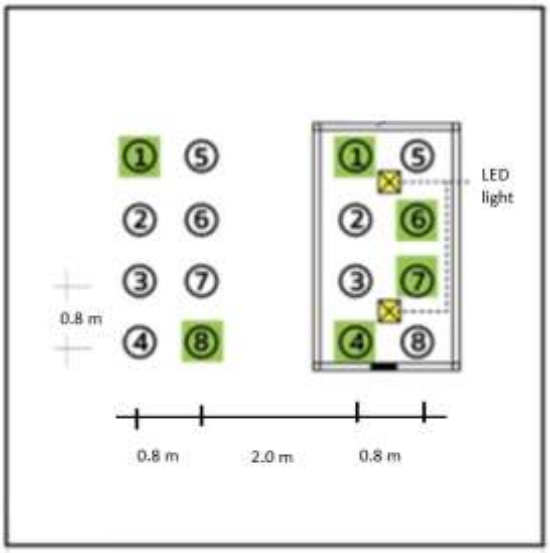

Fig. 1 – Plantation diagram used in this study.

2.2 Collection of Data

A daily light integral (DLI) was measured by DLI meter. A plant height was measured every one weeks after planting the sprouted seeds. The *C. sativa* flowers were collected for weighting and CBD content analysis at thirteen weeks after planting.

2.3 Analysis

The flowers of the *C. sativa* were ground into powder and then extracted with 95% ethanol. The extractants were separated by 0.22 μm nylon filter before injection into HPLC. The CBD compound was determined by HPLC (PerkinElmer, MA, USA), using a Quasar SPP C18 column instrument. The CBD compounds were analyzed using a previously described methodology (Hirunyasiri et al., 2024). Detection was carried out with a DAD (280 nm). The gradient program for mobile phase A (0.1% formic acid in a water) and mobile phase B (0.1% formic acid in a methanol) was adjusted at 0–18-min, 90% B; 18.0–19.8-min, 95% B; and 19.8–20.0-min, 75% B.

2.4 Statistical Analysis

The comparison between natural light and nighttime supplemental LED groups were subjected to an independent t-test using SPSS 18.0 software (SPSS statistical package, Chicago, IL, United States). The statistical significance of the results was analyzed at the 0.05 level.

3. Results and Discussions

3.1 Daily light integral (DLI)

Every day, an average DLI value from the *C. sativa* plantation was measured and determined to obtain the mean values. The results revealed that the DLI of natural light was 17.81±2.45 moles/m^2/day, which was not substantially different ($p>0.05$) from the nighttime supplementary LED group (19.72±2.18 moles/m^2/day), as presented in Table 1. However, the nighttime supplementary LED group's DLI value differed by 10.72%.

Table 1. The DLI value of the environmental plantation of this study.

Treatment	Average exposure DLI (moles/m^2/day)
Natural light	17.81±2.45[a]
Night-time supplemental LED	19.72±2.18[a]

The letter a indicates no difference between the 2 experimental groups at the 95% significance level.

3.2 Effect of night-time supplemental LED light on the growth of the C. sativa

Supplemental LED light for 8 hours for photoperiodic hemp revealed no significant difference in the high of C. sativa (Table 2). The height of photoperiodic hemp grown under natural light was 70.80±11.12 cm, whereas the plant grown with nightly additional LED was around 83.60±17.05 cm tall. The LED extensions both produced plants with mean tall 18.08% greater than plants grown under non-extended days. This corresponds with previous research (Fraser et al., 2023), showing that the LED treatments did not significantly affect *Capsicum annuum* var. *Seminis* hybrid sweet pepper PS 0941819 growth.

Table 2. The effects of LED light on the average of the *C. sativa* tall.

Treatment	Height (cm)
Natural light	70.80±11.12[a]
Night-time supplemental LED	83.60±17.05[a]

The letter a indicates no difference between the 2 experimental groups at the 95% significance level.

3.3 Effect of night-time supplemental LED light on the yield of the C. sativa

Light treatment had a non-significant ($p>0.05$) impact on the flower yield of the photoperiodic hemp (Table 3). The results of our study showed that the additional LED extensions time could not stimulated the production of flower in *C. sativa*. This was contrasted to the work of Wei et al. (2021), which showed that suitable ratios of red to blue LED light can greatly improve the biomass of inflorescence of *C. sativa*. Moher et al. (2021) suggested that the percentage of flowering *C. sativa* was highest under 12.0- and 13.2-hour treatments. As a result, 8 hours of supplementary LED light were insufficient to increase inflorescence photosynthesis and biomass.

Table 3. The effects of LED light on the flower yield of the *C. sativa.*

Treatment	Dry inflorescence weight (g)
Natural light	29.00±9.77[a]
Night-time supplemental LED	29.40±11.84[a]

3.4 Effect of night-time supplemental LED light on the CBD content of the C. sativa

The concentrations of CBD increase with the extension of light in the night-time by LED light, as presented in Table 4. The highest level of CBD in *C. sativa* -Auto-blue variety has been obtained with 10.31±0.33 %, which was higher than that of natural light treatment group by 20.87%. Supplemental illumination solutions have been shown to boost photosynthesis both below and within the canopy (Appolloni et al., 2021). However, during the daytime, some light might be saturated for plants and even wasted when natural light was strong at midday (Tewolde et al., 2016). Therefore, the increase of CBD content might be the enhancement of the photosynthesis by the supplemental LED light in the night-time.

Table 4. The effects of extensional LED light on the CBD content of the *C. sativa.*

Treatment	CBD content (%)
Natural light	8.53±0.12[b]
Night-time supplemental LED	10.31±0.33[a]

The letters a and b indicate the difference between the 2 experimental groups at the 95% significance level.

4. Conclusions

The comparative effects of the night-time supplemental LED light on growth of *C. sativa* -Auto-blue variety and the CBD content was investigated. The results of this study show that the application of the night-time supplemental LED light for 8 hours significantly increased the CBD content of *C. sativa*

-Auto-blue variety. However, the plant height and flowering yield of *C. sativa* -Auto-blue variety was non significantly improved by the night-time supplemental LED light. These results can be investigated further on a field trial and the extension time.

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