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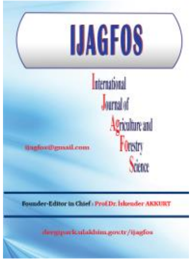

Research Article

Developing of DLI(Daily Light Integral) and Spectrum Control Systems for Scientific Cultivation in Agriculture#

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Abstract: This study presents a DLI (Daily Light Integral) and Spectrum-Based Scientific Cultivation Control System (DAS) Development, Design and Application of Luminaire. Effective planning and monitoring of the environmental conditions of plant growth have vital importance in terms of efficiency and control. Nowadays, beyond the control systems that are mainly focused on climate and fertilization, providing control of the quality and quantity of light plays a key role in terms of productivity and quality. From this perspective, In order to strengthen growing process or to manipulate positively, the amount and spectral properties of the light for the lack of / need for status enhancing plant growth by simulated or definition of scenarios for certain wavelength resolution to develop to be controlled aiming methods and technology will be managed by a control system DAS that is the main focus of the research and development of the study. Thanks to DAS, It will be possible to manage and control the greenhouse by modern agriculture techniques and maintain all of the growing process within the specified conditions and with determining the limiting factor of the plant breeding. Thus, The System will also provide a remedy for the further studies on the growing conditions of the plants in the greenhouses, either directly or indirectly affecting by the geographic or the climatic situations (insufficient amount of light, the wavelength of the light is not sufficient to affect the growth process, etc..).

1. Introduction

DAS consist of the DLI (Daily Light Integral), sensors, database, control unit, DALI and tree important data light intensity, light quality and light duration. For plant growth

•DAS algorithm to determine the necessary light values for the growth of plants where the natural light is insufficient for use in greenhouses

•To ensure that an optimum level of control of plant growth and LED armature

•Plant development or strengthening of manipulating the amount and spectral properties of the light for the lack / need situation or scenario defined in line with defined wavelength resolution, and techniques for the development of technologies to be checked

Using LEDs as a lighting source, it is possible not only to optimize the spectral quality for various plants and different physiological processes, but also to create a digitally controlled and energy efficient lighting system [1, 2]

Plants require light throughout their whole life-span from germination to flower and seed production. Three parameters of grow light used in greenhouse industries are relevant: quality, intensity and duration. All three parameters have different effects on plant performance [3]

Plants do not absorb all wavelengths of light (solar radiation), they are very selective in absorbing the proper wavelength according to their requirements. The most important part of the light spectrum is 400 to 700 nm which is known as

photosynthetically active radiation (PAR), this spectral range corresponds to more or less the visible spectrum of the human eye [4].
Plants are exposed to a variety of spectral qualities governed by geographical location, seasonality, changes in cloud patterns, and effects of surrounding vegetation. Additionally, plants under greenhouse cultivation in areas where natural light is not sufficient to grow a productive crop are exposed to significant changes in spectral quality caused by supplemental lighting with spectra dissimilar to natural light (Hogewoning, 2010). Plant responses to the light spectrum can be generally classified in two major aspects: growth responses and photomorphogenic responses. The growth responses are governed by the photosynthetically active radiation composed of wavelengths between 400-700 nm. The photomorphogenic responses are generally triggered by the blue (400-500 nm), UV (250-380 nm) and the interaction of red (600-700 nm) and far-red (700-800 nm) wavelengths.[5]

2. DLI(Daily Light Integral)

The term Daily Light Integral, or DLI, is used to describe the total quantity of light delivered over the course of an entire day. The daily light integral is reported as the number of moles (particles of light) per day, thus the unit is reported in trade journals as “moles/day” or in scientific publications as “mols/m²/day”.[6]

Increasing the amount of appropriate limits DLI;
•The increase in mass of the plant (root, branches, flowers etc.).
•Shortening the time of flowering
•The plant's branching volume gain
•It may tend to increase the size and number of flowers.

2.1 Plant Growth

The quality, intensity, and duration of light directly impact plant growth.
Light quality, refers to the color or wavelength reaching the plant's surface.
Light Intensity, The more sunlight a plant receives, to a degree, the higher the photosynthetic rate will be.
Light Duration, refers to the amount of time that a plant is exposed to sunlight. [7]

2.2 Equations

PPFD (Photosynthetic Photon Flux Density) represents a field measurement and is defined as, the number of photons in the PAR region emitted per m² per Second.(μmol/m²s)

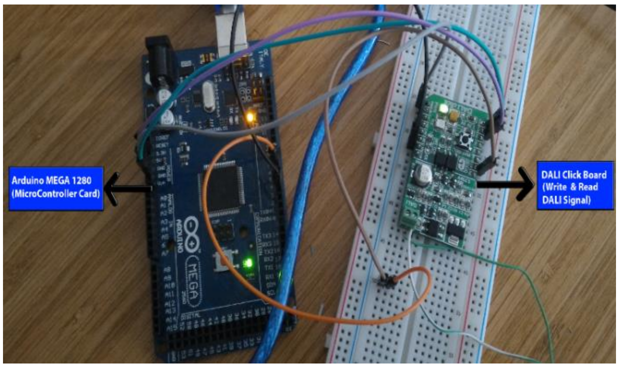
DLI (Daily Light Integral): is used to describe the total quantity of light delivered over the course of an entire day. (Mols/m²/day)[8] The formula should be as equation 1.

$$\text{DLI (Watt/m}^2\text{)} = \text{TOTAL INTENSITY} \times 0.0036$$
$$\text{DLI (mols/day)} = \text{Watt/m}^2 \times 2 \quad (1)$$

Note: 0.0036 comes from 60 seconds/min X 60 min/hr / 1000000 micromole/mole

3. DAS (DLI Spectrum Automation System)

The DAS is given in Fig. 1. The developed control card, which consists of a ARDUINO MEGA 1280, MICROELECTRONICA DALI click card for driving the Led driver and LED, is seen in Fig. 2(a). Fig. 2(b) Oscilloscope shows the DALI signal. Fig. 2(c) DAS sunlight PAR is compared to its reference within the microcontroller. As a result of this comparison, DAS are determined. If the sunlight is higher than the reference, then the Led is turnoff and it is kept turnoff position until the sunlight PAR falls below the reference. Both led and led driver are driven by the DAS.[9]



(a)

(b)

(c)

Figure 1. *Experimental system (a)control card (b) DALI signal (c) DAS*

Flowchart of the presented technique is given in Fig. 2 firstly choosing plant that will grow. This plant database is named X. Then, the sunlight PAR is read QUANTUM sensor, If the measured PAR is above X, the LED module is TURN OFF. Once the sunlight PAR drops below X, the system compare sunlight PAR with X. Then determine the LED value and drive the circuit for as much light as you need. All of them monitoring in our program which is written in C#.NET.

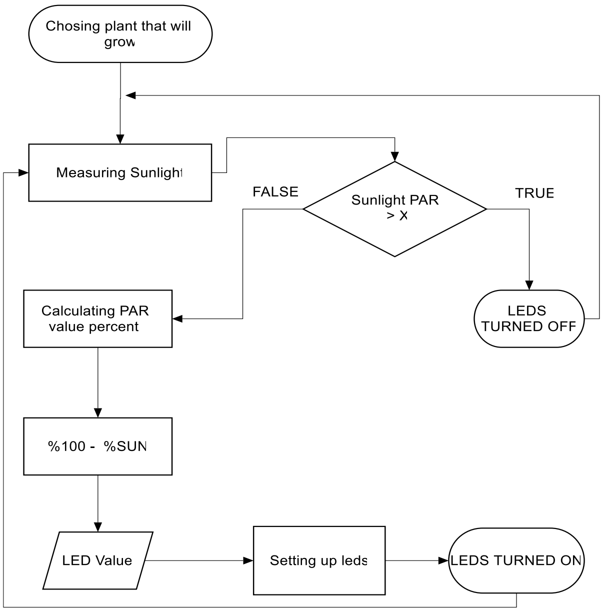


Figure 2. *Flowcharts of the DAS algorithm.*

Flowchart of the DAS block diagram is given in Fig. 3.First the intensity and quality of the sun is measured. It uses APOGEE-SQ110 quantum sensor and STELLARNET-BLACKCOMET spectrometer. Then, it performs control operations according to the control unit plant DB and hardware DB. According The DAS interface drives the Led Groups with DALI, which is informed the Control Unit. DAS uses OSLON SSL 150 CQDP blue and OSLON SSL 150 CPDP red led group.[10]

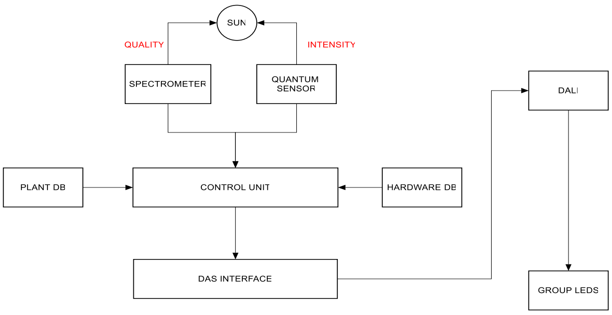


Figure 3. *DAS block diagram.*

4.Experimantal Results

In the experimental studies, PAR value of sunlight is measured by spectrometer at different times. Plants use light between 400-700 nm. The obtained results using the PAR is given in Fig. 4 where is 10:00am, 11:30am, 01:00 pm, 02:15pm, 03:30pm and 05:00pm

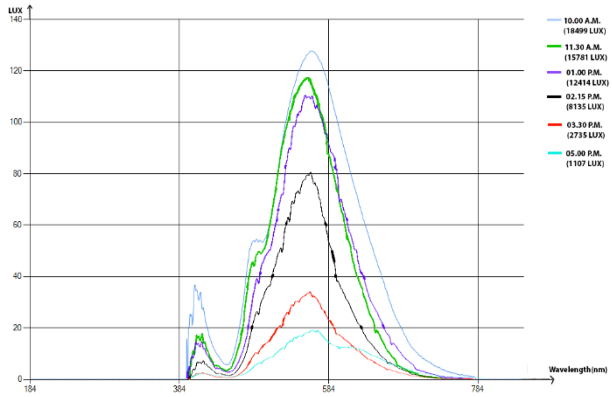


Figure 4. *Experimental results for SUNLIGHT.*

In Fig.5, After PAR value of LED is measured by spectrometer. For plants, blue light is at 400-450nm, red light has wavelengths between about 630-700 nm.

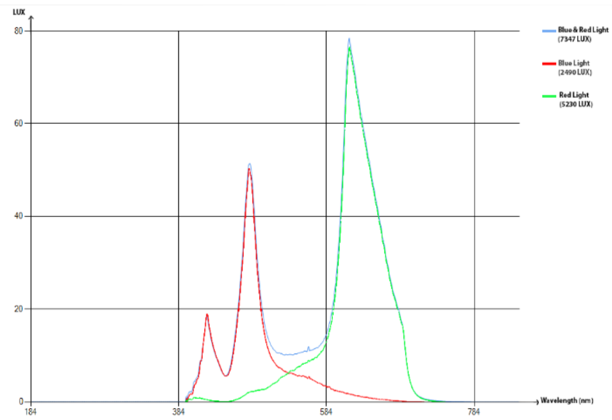


Figure 5. *Experimental results for LED.*

5. Results and Conclusions

The Study output DAS is mainly an automation application which will provide an integrated growth support system expected to be used mainly for greenhouses to recreate the ideal required light parameters, even if the natural light is not enough for the plants.

In this respect, for the growth of plants, besides the power of light energy either natural or artificial, it is aimed to ensure an optimum level of control of plant growth and LED armature by the necessary light values where the natural light is insufficient for use in greenhouses, optimizing both the spectral quality for various plants and different physiological processes, creating a digitally controlled and energy efficient lighting system.

As a result, in the process of growing plants, in which this parameter plays a limiting key role, this system will make it possible to get a better yield amount by optimizing identical natural or keeping on stable level determined.

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