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Artificial Lighting for Plants (ALP)

Afaq Ahmad[1], Sougata Banerjee[1], Aniruddha Mukherjee[1*] and Amit Soni[2*]

[1]Department of Electrical Engineering, University of Engineering & Management, Jaipur.
E-mail: mukherjeeanirudh73@gmail.com
[2]Department of Electrical Engineering, Manipal University Jaipur, Jaipur. E-mail: amitsoni_17@yahoo.co.in

Abstract

Agriculture is the backbone of Indian economy. India has marked itself self-sufficient in food. But the large population of India is always keeping a constant demand in the market for food. Also, with the growing industrialization and urbanization, agricultural tracts are becoming fewer in number. Hence, the supply of food has put over-utilization of the existing agricultural lands. There has been a constant effort in the research and development sector of agriculture in India. Most of the rural people in India practice agriculture.

Artificial Lighting for Plants (ALP) is the concept of growing a plant in light (other than sunlight), with all the other factors like moisture, soil nutrition, etc. Using the ALP device, a farmer can monitor the plants regularly. Also, distinguished light can be executed for different kinds of plants. Hence, ALP device not only lets one to boost the production, but also maintain good health of the plant for ensuring quality as well as quantity.

Keywords: *Agriculture, artificial lighting, light, plants, spectrum.*

1.0 Introduction

Surfing through the data provided by FCI, it clearly states that India is one of the most populous countries in the world with estimated population of about 1.28 billion. It is the seventh largest country in the world with an area of 3.288 million square kilometers. Agriculture accounts for 23% of the gross domestic product, and employs 59% working people of the total employment in 2016. Agriculture, along with its ancillary sectors, is the traditional and rich source of livelihood in India. 70 per cent of its rural households look primarily on agriculture for their livelihoods till now where 82 per cent of farmers are small and marginal. In 2017-18, total food grain production was calculated and was found to be 275 million tonnes. India is the largest producer (25% of world gross production), consumer (27% of world gross consumption) and importer (14%) of pulses in the world. The increase in food production was due to institutional efforts to raise the level of technology used in agriculture through research and extension, investment in rural infrastructure and human capacity, credit assistance, procurement at minimum support price and strengthening of subsidiary institutions[1].

Research in the artificial lighting for plants says that the optimum growth of a specific plant is obtained when the pigments and photo-receptors absorb their specific wavelength of light spectrum, provided with proper water and nutrition[2]. Artificial lighting and agriculture are two different sectors, but provide the utmost benefit when combined together. Agriculture with scientific methods has proven much better[3]. Analyzing the crop patterns, tiling, sowing, nutrition and harvesting stages, implementation of scientific gadgets and equipment have boosted the production along with quality[4]. It helps producers to maintain financial requirements. It erases losses in agriculture. Introduction of Internet of Things (IoT), Automation, Smart Irrigation, etc have lend a helping hand to scientific agriculture.

[*]Author for correspondence

2.0 Concepts

Light Spectrum Aid Towards Growth of Plants

Light is a free form of energy. It travels in wave form. It is a form of electromagnetic wave. Every electromagnetic wave has a particular wavelength, frequency and amplitude. When white light is passed through a prism, it dissipates into seven distinguished colours. This is called the spectrum of light. Human eye is able to see only the visible spectrum of light whose wavelength varies between 400 and 700 nm[5].

The basic procedure of food manufacturing in plants is known to all of us. Plants are auto-tropic in nature. They make their own food and store in them. Macroscopically the cycle looks very simple. In the presence of sunlight, plants make food on their leaves. Water and nutrition come from the roots through xylem and phloem and carbon dioxide is available in the air. The green pigment present on the leaf, called chlorophyll, helps in making food. Food is prepared in the form of Glucose and stored within the plant body itself. During absence of sunlight, plants use their stored food for growth[6].

However, plants absorb the red and blue wavelengths of light and reflect a greenish look[7]. In the presence of light, plants convert water and carbon compounds to complex organic sugar and oxygen through photosynthesis process. Chlorophyll present in the intra-cellular organelles called chloroplasts are green Coloured organic elements. Most of the plants absorb chlorophyll a and chlorophyll b and hence, reflect green colour[8, 9]. Artificial light for agriculture and crop cultivation has attempted to resemble sunlight in the visible light spectrum. Nowadays, artificial lighting is mainly done through LEDs (Light Emitting Diodes). LEDs are available in abundant, cheap and has long life. Preferred range of lights are available in LEDs like red, pink, blue, white, warm white, green, etc. Artificial lighting has improvised the agriculture in a large-scale. Different plants are cultivated using ALP much efficiently.[10][11]

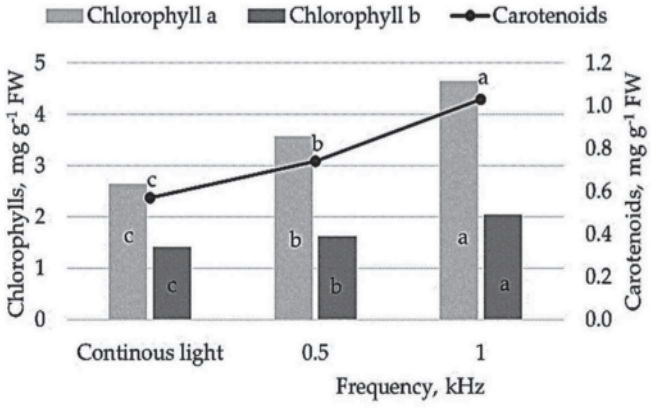

Figure 1: Effect of Continuous Lighting on different Chlorophyll components

Artificial Lighting for Plants (ALP) Device

ALP is an Arduino based project where multi-functional LEDs, Multi-functional LED products combine three colours (Red, Green and Blue) to produce over 16 million hues of light. There is a LUX sensor that is fitted near the plants to cross-check the wavelength of light emitted from the LEDs and the wavelength of light reaching the plant. Through Arduino, a specific wavelength of light can be provided to the plant. Also, the wavelength at which the plant growth is optimum can be observed.[12] Soil moisture sensor is a sensor connected to an irrigation system controller that measures soil moisture content in the active root zone[13]. At the top center of the plant a camera module (ESP32-CAM is a low-cost ESP32-based development board with onboard small camera) is fitted. The board integrates Wi-Fi, traditional Bluetooth, and low power BLE, with 2 high-performance 32-bit has set up, it clicks photos of the plant after a certain time and sends to the connected device for digital image processing. Artificial Intelligence aligned with digital image processing is a method to perform some operations on an image, to get an enhanced image or to extract some useful information from it. With this information we can monitor the growth of the plant detect the optimum luminous range for the type of plant through AI or any unusual activity or disease of the plant[14]. The ALP device is an indigenous device to not only monitor the growth of plants but also ensures better productivity, enhanced quality and nurtured soil properties. With its entire features, the ALP can be considered the best artificial lighting agricultural product that is smart, better and more efficient.

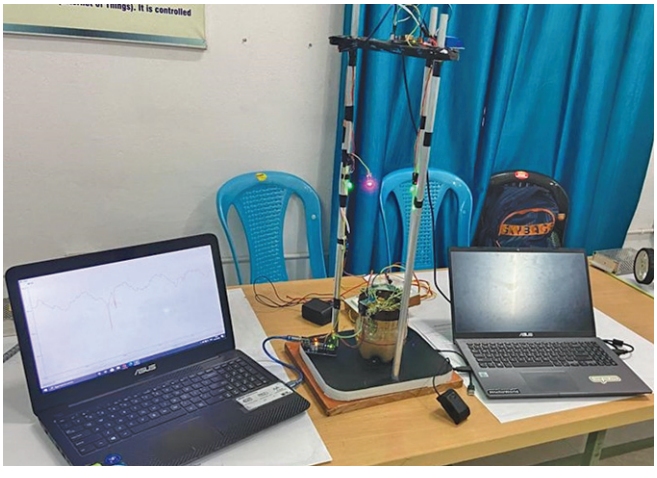

Figure 4: ALP device, two output devices for LUX and Soil properties

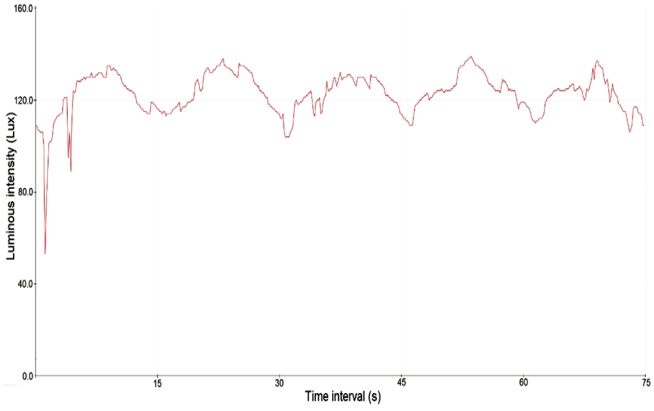

Figure 4: Light from LEDs reaching the plant with respect to time

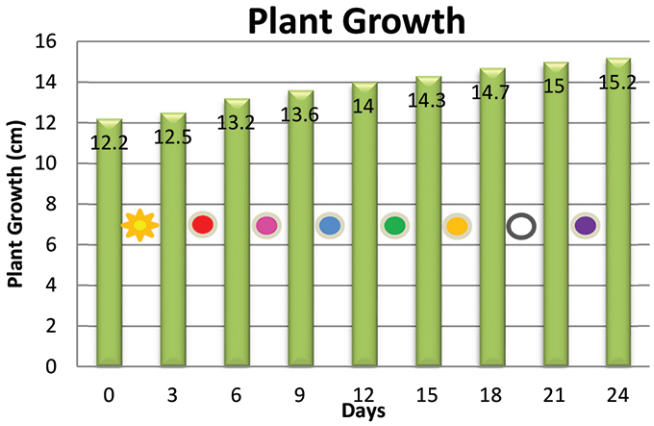

Figure 5: Graphical representation of obtained data

Table 1: Light emitted vs. Light received at plant nodes

LUX at Plant	293	343	394	445	492	544	596	645	691
LUX emitted	300	350	400	450	500	550	600	650	700

Table 2: Plant growth (height in cm) in different Colour spectrum of light

Days	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Light	Sunlight	Red	Magenta	Blue	Green	Yellow	White	Violet
Growth	12.5	13.2	13.6	14	14.3	14.7	15	15.2

When any plant is cultivated under the ALP device, it comes under the camera module. The camera module works with artificial intelligence (AI) technology to identify the type of plant. After the successful identification, it stimulates the light range to optimize the growth of the plant. In this way, AI makes the process automatic and smart. The light emitted from the LEDs reaches the plants and help in growth. There are light intensity sensors along the plants to get the actual luminous intensity that reaches the plant with respect to time. In the experiment, the light range was constantly changed with time to get the actual growth of the plant, monitored through the camera module. The other sensors fitted along with system, like, soil moisture sensor and soil temperature sensor, provide constant data about the soil properties. Whenever the desired moisture level is low, the processor (Arduino) automatically operates the small water supply pump to the soil. Through an output device, a constant check can be observed to see the whole process.

3.0 Results

A bunch of data is recorded on the basis of experiments done.

First, the Table 1 provided shows the difference in luminous intensity from emitted to that reached the plant. A graph is plotted against the results observed, which is also provided in Figure 2. Conversion used: 1 lux = 1.4641288433382E-7 watt/cm^2

4.0 Conclusion

On the whole, the ALP device is smart enough to provide the all types of data regarding the plant, cultivated artificially. It provides real-time data. Implementation of IoT in it will make it accessible from any corner of the world. Lights can be altered as per plant, soil moisture and minerals is automatically maintained and plant growth is observed remotely time to time in the ALP device. All the data available for the specific type of plant that grows optimum in specific wavelength of light is fed into the device. The device takes care of the plant all the time. Thus, the plant is nurtured every moment. This surely improves the quality and quantity of production. Artificial Lighting agriculture, smart irrigation system, Biotechnology, Modern farming tools and equipment, application of Artificial Intelligence (AI) and Machine Learning (ML) with IoT in Industry Plant Agriculture and Greenhouses, etc; have proven things much better.

5.0 Acknowledgements

Research is an integral part of any development. Searching new aspect of existing technologies through research leads to new developments. Keen researchers, scientists and professionals are constantly contributing their efforts towards research in different fields.

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