Effect of Artificial Lighting on Growth of *Ipomoea Aquatic* for Indoor Hydroponic Farming

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Abstract— **In this study, the effect of artificial light intensity on growth of *Ipomoea aquatic* were studied. The objectives of this study are to determine the relationship between the growth of *Ipomoea aquatic* and artificial lighting intensity, design an appropriate hardware system using suitable sensors and evaluate the system performance. The experimental works were conducted correspondingly and results are tabulated. It is shown that the artificial lighting with the majority blue color LED is suitable compare to red based on the result output.**

Keywords-LEDs; hydroponics; Artificial Light; Plant

I. INTRODUCTION

In general, plants get energy from sunlight through a process called photosynthesis. The energy is needed for plants to grow. Normally, plants need lots of sunlight and should therefore be placed outside on a sunny environment. Plants with insufficient sunlight will affect the growths which indicate signs such as leaves turn yellow, stem will be leggy or stretched out, leaves are too small, and stems are spindly.

However, most of the vegetable plants only need low sunlight to grow. This is because many vegetable plants might not survive outdoors in poor weather conditions and drying out. Therefore, an artificial light is an alternative to grow the plants indoor.

From the literature review, many researchers [1-9] had developed systems that able to give options to gardeners. One of the method is hydroponic system with automate IOT to monitor the development of several plant [1- 3, 10]. Another research on the effect of artificial lighting for modern farming done by [8] had showed that the height of the plant, chlorophyll content in the leaves carbon dioxide release as well their water contains in the leaves of *Typhonium Flagelliforme* plants can be enhanced with the application of blue and red light spectrum of light emitter diode (LED), compact fluorescent light (CFL) with a wavelength of 475 nm and 650nm. In [9], the automation of hydroponic farming system is presented in which the monitoring system development involve the use of PH sensor, electro conductivity sensor, water temperature sensor, air temperature, light sensor and Ardunio Uno as main controller. The conditions of leaves and plant height of lettuce and red spinach are monitored using the developed system.

In this work, it is aim to develop an automatic artificial light for the growth of vegetable plants. The functionality performance of the developed device is then analyzed and discussed. Prior to that, the relationship between the effect of the artificial light and the growth of the plant is determined via experimental work.

The vegetable plant used in this work is known as *Ipomoea Aquatic*, commonly called Kang Kung in Southeast Asia. It belongs to the plant family of Convolvulaceae. It is a semi-aquatic tropical plant as a leaf vegetable [6]. The experimental work is conducted in the low light room at Final Year Project Laboratory, Faculty of Electrical Engineering, Universiti Teknologi Mara (UiTM) Shah Alam.

II. LIGHT SPECTRUM

The visible light spectrum wavelength [5] is as shown in Fig. 1. Each color on the visible light spectrum has varying effects on plant growth.

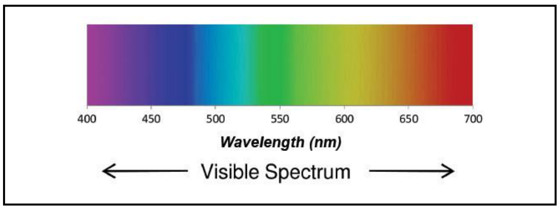


Fig.1 The visible light spectrum

Red and blue light are both used for photosynthesis. Blue light is mainly responsible for the vegetative growth or leaf and if combined with the red light, promotes flowering [4]. Some plants require high amounts of light to grow. The use of red light will increases plant growth and production when grown indoors. The yellow and green wavelengths are inefficient on plant growth. The green light makes them appear green.

In general, the best wavelengths for photosynthesis are blue light with a 450nm wavelength and, both blue and red light with 650nm wavelength. Meanwhile, the red and far-red light with 730nm wavelength is the best for flower and fruit production.

It is essential to have a combination of blue and red lights together for germination process to promote leafy vegetative growth. The use of blue light alone will degrade growth process.

III. Ipomoea Aquatic

The *Ipomoea Aquatic* is a tropical plant grown as a vegetable. It is commonly known as Kangkung in Southeast Asia as shown in Fig. 2.

Fig. 2: Ipomoea aquatic

As shown in Fig. 2, the leaves of Ipomoea Aquatic are smooth and shaped like an arrowhead. The leaf blade is approximately 5 – 15 cm long and 2 – 6 cm wide, while the petiole is about 3 – 14 cm long. In water, leaves are held above water. The stems are hollow and contain a milky sap.

The plants best grow in warm and humid environments. Specifically, it grows in a condition of constant temperature (25ºC), relative humidity (65%). It needs full sunlight and lots of water as the plants growth rate is very fast. The duration for seed germination only took 3 days for first leave shoot.

IV. Methodology

The methodology of this project is divided into three parts, namely the germination process, the development of the device and the device performance analysis and evaluation. The details are elaborated in the following paragraphs.

A. The Germination Process

The germination process is the process of seeds growing into plants. In this work, the process is essential to grow the first shoot of the plants. Three containers with two inches deep that filled with water are used for germination process. The seeds are put into germination sponge, in which, then soaked into water inside the container. Observation is then took place for 4 – 5 days. The height of the plants is measured.

The second stage of the work is the experimental work setup for artificial lighting to the plants. In this work, the experiment is conducted in the low light room with ambient temperature and humidity. The optimum environment for germination process is prepared in such a way as shown in Fig. 3.

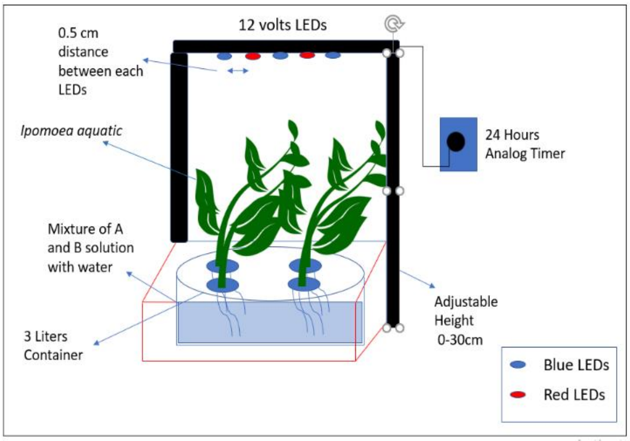


Fig. 3: Germination process setup

As shown in Fig.3, the containers are placed in a box with adjustable height for best utilize the space and lighting. There are 2 blue 12 Volt LEDs and 3 red 12 Volt LEDs mounted horizontally above the plants. This arrangement is to ensure maximum blue and red lights spectrums are absorbed for germination process. In this work, the plants are exposed up to 12 hours to the artificial lighting by using analog timer.

Observations are then took place for a week. The light intensity and the growth of the plants are measured and tabulated. The growth measurements are including the height of the plant, the growth rate and the leaves condition.

B. System and Device Development

The system block diagram is as shown in Fig. 4. In this work, there are four main electronic instrumentations used to functionalize the system device such as light intensity sensor BH-1750, HR-SR04 ultrasonic sensor, 12V 3 blue LEDs, 12V 2 red LEDs and Arduino Uno.

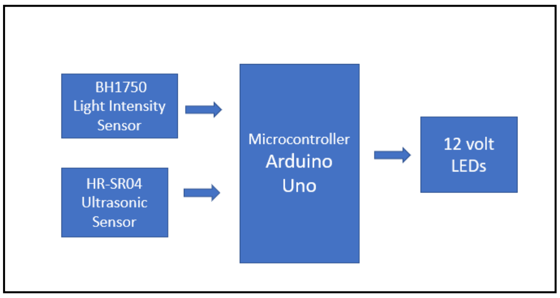


Fig. 4: System block diagram

The BH1750 is used to measure the light intensity of the LEDs. It has a 16-bit A2D converter built-in that can directly output a digital signal. The output is in a unit of Lux (Lx) and does not require calculations.

HR-SR04 is a ranging sensor with 2cm to 400cm of non-contact measurement. The ultrasonic sensor is used to measure the height of the plant and control the intensity of the LEDs intensity by using Pulse Width Modulation (PWM). In this work, the LEDs will be adjusted manually in the range between 1.0kLx to 1.5kLx, 1.5kLx to 2.0kLx and 2.0kLx to 2.5kLx. The corresponding PWM is then observed and tabulated.

Arduino Uno as shown in Fig. 5 is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins in which 6 pins can be used as PWM outputs and 6 analog inputs. In this work, Arduino Uno is used as a microcontroller that controlling the LEDs using ultrasonic sensor and light intensity sensor.

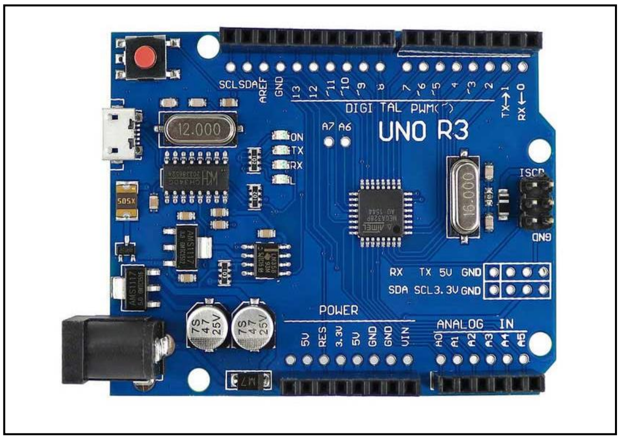


Fig. 5 Arduino Uno

The system arrangement is as shown in Fig. 6. The light intensity sensor is placed in between the LEDs and the plants at appropriate distance. The LEDs setting is as shown in Table I.

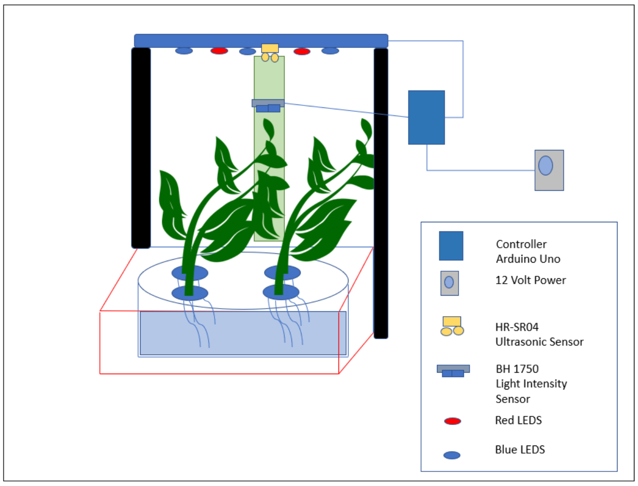


Fig. 6: The system arrangement

TABLE I. LEDs Setting

No.	LEDs setting		
	Light Intensity(kLx)	***Number of Red and Blue LEDs (R,B)***	***Ratio of Red and Blue LEDs (%)***
1	1.0~1.5	5B,2R	70% blue, 30% red
2	1.5~2.0	5R,2B	70% red, 30% blue
3	2.0~2.5	3R,3B	50% red, 50% blue

The system operational is as shown in Fig. 7. The flowchart defines the working system where it starts with measurement of the distance between maximum peak of the plant with the intensity of the light. 1~1.5kLx light intensity will be the benchmark of the LEDs and the system will operate 12 hours daily until the plant reached the maximum height.

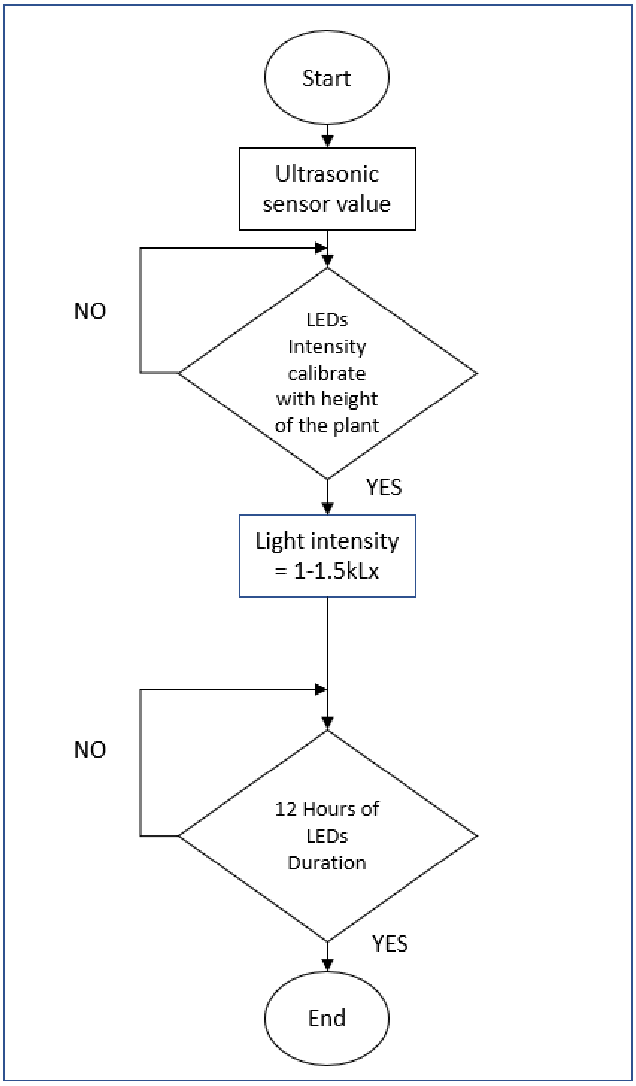


Fig. 7 Flowchart of system operational

C. Device Functionality Performance Evaluation

The functionality of the device is tested in term of the ability to measure and display the amount of light intensity supply to the plants. It is to conform the operational of the device is sufficient and accordingly by using actual digital light intensity meter. The light intensity sensor has a different value with the digital meter with 100~200 lux. The digital meter has the accuracy of ±5% with the range of 0~100kLx while the light intensity meter has the accuracy of ±9% with the range of 0~65 kLx.

V. Result And Discussion

A. The Germination Process

The result of germination process is shown in Fig. 8. It is observed that after 4 – 5 days, the growth is about 3 – 4 centimeters under normal and low light room.

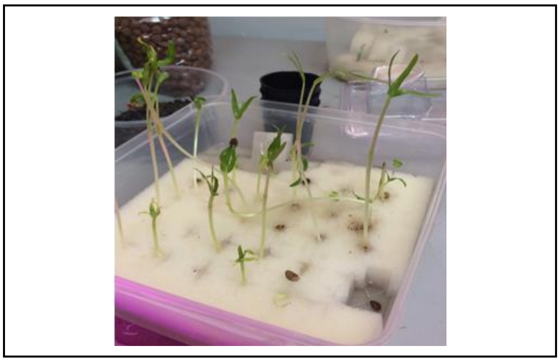


Fig.8: *Ipomoea aquatic* after 4 – 5 days

TABLE II. Growth of *Ipomoea aquatic*

No.	Growth of Ipomoea aquatic				
	Light Intensity(kLx)	***Weekly Growth (cm)***			
		Week 1	***Week 2***	***Week 3***	***Week 4***
1	1.0~1.5	3.0	8.0	21.0	30.0
2	1.5~2.0	2.0	7.0	20.0	28.0
3	2.0~2.5	3.0	7.0	17.0	21.0

Table II: Growth of *Ipomoea aquatic*

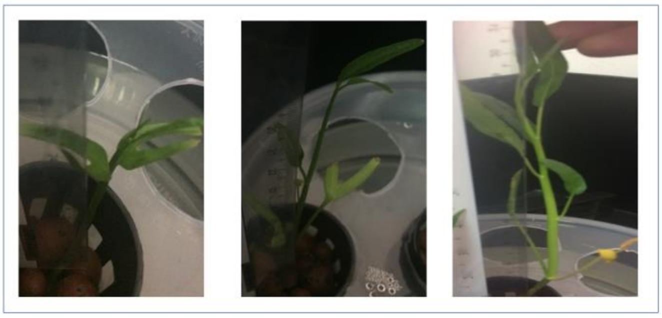
Table II and Fig. 9 shows the results of germination process under variations of light intensity and plants growth respectively. It can be seen that within 4 weeks, the growth is up to 30 cm height.

For the first crop in Fig a. By using 1.0~1.5kLx light intensity with the ratio of 30% red and 70 % blue LEDs, it was the highest crop among of all the experiment. The plant growth rate per day is 2.067cm and shown that blue LEDs is suitable for growing leafy crop. The leaves also have the less leaf scorching which proven that the plant is not direct light receiving. The distance between the LEDs and plant ranging from 7~10cm to maintain the light intensity

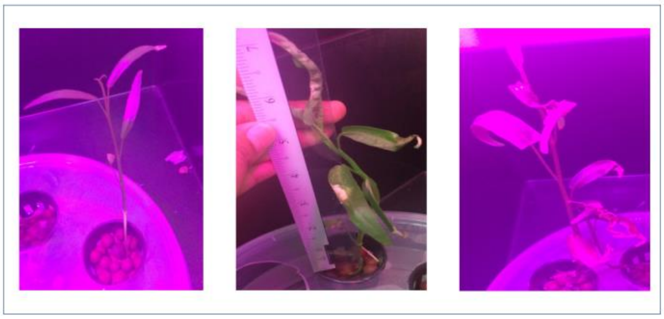
Meanwhile, for the 1.5~2.0kLx light intensity with the ratio of 30% blue and 70% red LEDS in Fig b. The growth is in moderate condition with 1.9cm growth per day. Using the red LEDs as majority colors shown that it is less suitable for vegetative grow and one of the leaf turned yellowish color. The reason is because of the plant was exposed to the light in a medium range with the distance of 4~7cm.

Plant that used 2.0~2.5kLx light intensity with ratio of 50% blue and 50% red LEDs in Fig c. The plant was in poor result with 1.6cm growth rate per day. The condition of LEDs was almost directed to the crop with the ranging distance of 1~4cm. The result shown that majority of the leaves experienced leaf scorching and this is the effect of direct light applied to the leaves.

a) 1.0~1.5kLx plant growth



b) 1.5~2.0kLx plant growth



c) 2.0~2.5kLx plant growth

Fig. 9: Weekly Observation Growth of Ipomoea Aquatic

From the results, it shows that the variations of light intensity influence the growth of Ipomoea aquatic. Excessive light that exposed to the plant will result yellowish leaves and degrade the growth rate.

B. *System and Device Functionality Performance*

The developed system device is as shown in Fig. 10 will control the light intensity suitable for the plant and measured using the adjustable pole.

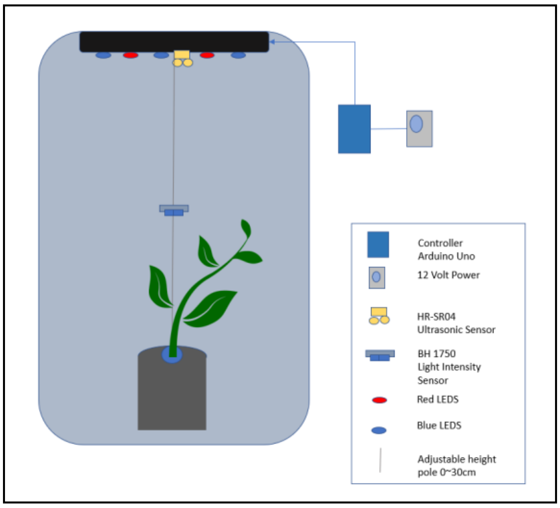


Fig. 10: Developed System Device

The light intensity 1.0 – 1.5kLx and the corresponding PWM are plotted as shown in Fig. 11.

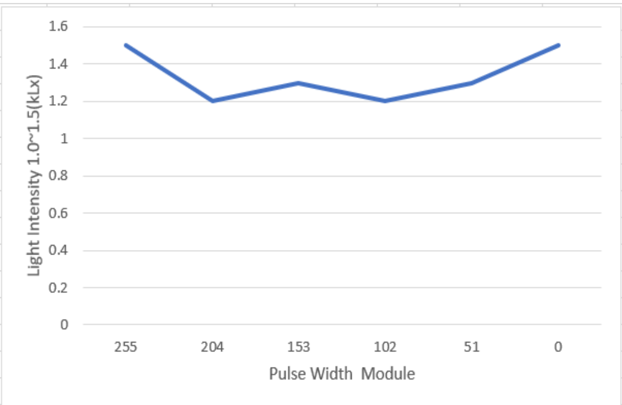


Fig. 11 PWM vs Light intensity 1.0~1.5kLx

The height of the plants vs light intensity for all ranges as shown in above figures. For the light intensity 1.0~1.5kLx has the most stable growth compare others.

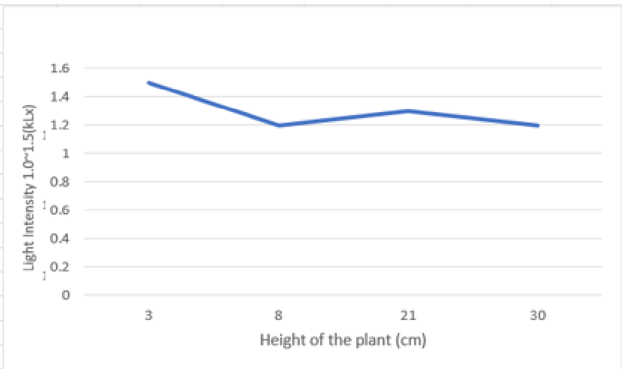


Fig.12 Height of the plant vs Light intensity 1.0~1.5kLx

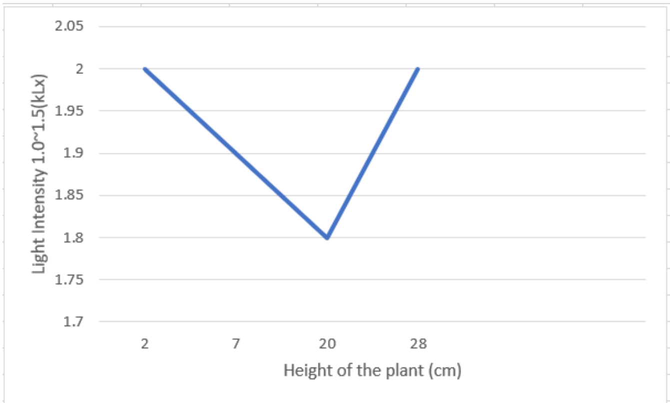


Fig.13 Height of the plant vs Light intensity 1.5~2.0kLx

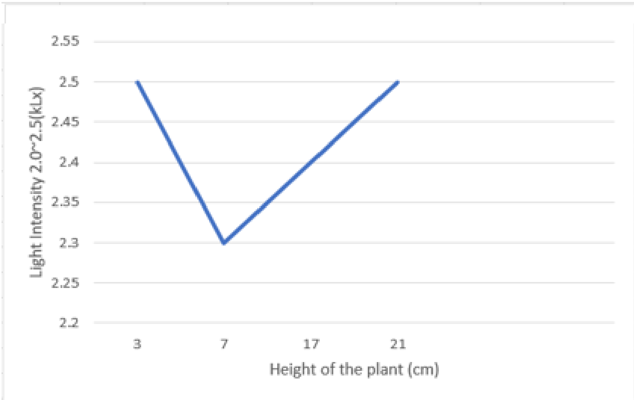


Fig.14 Height of the plant vs Light intensity 2.0~2.5kLx

VI. Conclusion

The system device design is successfully developed. The results had showed that the device functionality is accordingly.

It is also proved that the artificial light able to replace natural sunlight for the plants growth. The variations of light intensity influence the growth of the plants.

It is also proved that excessive light spectrums to the plants will result yellowish leaves and degrade the growth rate.

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